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LEAST SQUARES POLYNOMIAL REGRESSION WITH CONSTRAINTS: A COMPUTER PROGRAM

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The least squares polynomial regression constraints program LSPRWC presented in this report is a computer code written to perform a least squares polynomial regression on a given set of data pairs or observations with the option to impose constraints on the regression polynomial. The FORTRAN 77 computer program listing, as well as detailed information on theory, program structure, and limitations, are given along with two sample cases.

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I. INTRODUCTION

LSPRWC is a FORTRAN 77 computer program written to perform a least squares polynomial regression on a given set of
(x, y) data pairs or observations. In common parlance, LSPRWC, a "curve fit" procedure, finds that n_p order polynomial

$$P(x) = \sum_{j=0}^{n_p} b_j x^j$$

which minimizes the sum of the squared errors, the squared residuals, between the polynomial value $P(x)$ and $y(x)$ over the set of (x, y) data pairs.

In addition, LSPRWC provides for the imposition of constraints on $P(x)$ such that the n_c derivative of $P(x)$ may be specified at a given x location.

LSPRWC was written for LINUX[1]/UNIX[2] users as an analysis tool in science and engineering. The program was intended for users who care about numerical precision, wish to have a well documented source code in hand, and abhor spreadsheet calculations and license fees.

LSPRWC requires command line interaction. No graphical user interfaces are provided with the computer program—although they could certainly be added. The code was not meant for the "point and click" community of computer users.

Least squares polynomial regression is a well known analytical technique dating back to at least the 18th century[3]. The technique remains a premier method for the functional approximation of presumably repeatable phenomena when observations of that phenomena are known to be imperfect. The technique is also commonly used to quantify those phenomena which either defy description by the known laws of physics or for which the mathematical descriptions are simply too unwieldy or numerically intensive for practical application.

Although the functional form for linear regression need not be based on polynomials, polynomials have proven to be particularly useful for a broad range of applications. Additionally, the closed-form mathematical solution for $P(x)$ is readily derived, as given in Appendix A. Once the b_j coefficients are known, polynomial evaluation reduces to a simple numerical process. Furthermore, it is relatively easy to compute derivatives and other properties, such as arc length and integrals for polynomials.

LSPRWC was specifically written for source code control, source code that is readily tailored for specific applications, and to maintain ease of use with the advent of new computational platforms and operating systems. As such, the code eliminates those inexplicable fee requirements for licensed software which exploits an analytical technique embodied in the public domain for centuries.

The addition of constraints was added to LSPRWC as a particularly useful capability not usually included with commercial least squares regression software packages. Often as not,

some physical constraint—an initial condition such as zero velocity and a second derivative such as gravitational acceleration—are known absolutely and can be included with LSPWRC to better approximate a given phenomena.

LSPRWC, as written for LINUX/UNIX operating systems, requires only a FORTRAN 77[4] compiler and a terminal window system such as the *X Window System*[5]. The code is known to compile successfully with the Free Software Foundation G77[6] compiler and to work well on *Apple Mac OS X*[7] and *Yellow Dog*[8] LINUX computer operating systems. Although written to FORTRAN 77 standards, the code may compile with FORTRAN 95[9] compilers and does so with the Intel ifort[10]compiler. LSPRWC memory and disk storage requirements are flexible and readily adjusted.

The LSPRWC computer code is not guaranteed to run successfully or operate without failure on any given computer and/or operating system. Considerable error messaging is included in the FORTRAN 77 code, but this does not assure that the linear regression process operates as intended. Hence, it is advised that the user first execute test cases with known solutions for comparison with the LSPRWC code output.

II. FEATURES

The LSPRWC code was written to provide a user friendly environment while offering extensive analytical capabilities by means of the following features:

- Full directives are written to the terminal window whenever input to the LSPRWC code is requested.
- All operational parameters are input using either NAMELIST or free field reads.
- Input to the LSPRWC code from formatted disk files may be offered as an option. In such cases, the data file format, including free field reads, will be input from the command line.
- Sets of (x, y) data pairs are entered either by NAMELIST or read from a formatted disk file.
- Optional constraints are input either by NAMELIST or read from a formatted disk file. Each constraint is defined by the derivative order $n_c = 0$ through $n_p - 1$, the x location for the constraint, and the value of the n_c derivative of $P(x)$ at the constraint location.
- Computational results from the linear least squares regression are output to the terminal window as the LSPRWC code executes. This output includes the values of the b_j coefficients of the n_p order polynomial $P(x)$ and the standard deviation of the (x, y) data pairs with respect to the regression polynomial.
- As an option, x values may be prescribed for evaluation of the resultant least squares polynomial. These x values may be entered by NAMELIST, input from a

formatted disk file, or alternatively as minimum, maximum, and interval values to produce an array of evaluated (x, $P(x)$) data pairs.

- A plot option is included in the LSPRWC code such that the user may visually compare the evaluated (x, $P(x)$) data with the (x, y) data pairs. No plot package is actually included with the LSPRWC code, but the two data sets, (x, $P(x)$) and (x,y), are written to formatted data files for ready access to the user's favorite plot package. The plot option subroutine QPS can also easily be modified by the user to include an in-line plot routine for execution with the LSPRWC code.

- Output of results from a LSPRWC run may optionally be written to a formatted disk file as either the entire set of run parameters, input data, and results or as simply the evaluated data. In the latter case, the evaluated data includes the choices of x, the 0 through n_p - 1 derivative value of $P(x)$, the radius of curvature, and the arc length as columnated data sets.

- Restart options are included in the LSPRWC code allowing for easy modification of operational parameters, for example polynomial order n_p, without having to re-enter all of the input information.

- Constraints are satisfied using the method of undetermined Lagrange Multipliers[11].

- The LSPRWC code includes a matrix inversion subroutine GJEMPS which is based on Gauss-Jordan elimination using a maximum pivot strategy[12]. With some minimal effort, the user may substitute their preferred matrix inversion technique should that be desired.

- All of the FORTRAN 77 array sizes are set in PARAMETER statements within the LSPRWC code making it relatively easy to find and change those array size limits should that be required.

- The LSPRWC code maintains 64-bit precision with IMPLICIT REAL*8 statements in each subroutine as required.

III. SPECIAL FEATURES

The following special features were added to the LSPRWC code to enhance the user friendly environment:

- If a simple Yes/No input is requested, then any upper/lower case variation of Yes, No, Y, or N provides a permissible entry as controlled by the FORTRAN subroutine YNOUS listed in Appendix C.

- Disk files to be used for LSPRWC code input may contain alphanumeric headers such as

Thermal Data Set

T(K)	P(Pa)
289.26111111111	0.18305580366000E+04
289.81666666667	0.18967477057200E+04
290.37222222222	0.19650058020000E+04
290.92777777778	0.20346428497200E+04
291.48333333333	0.21070378003200E+04
292.03888888889	0.21815011780800E+04
292.59444444444	0.22587224587200E+04
293.15000000000	0.23373226908000E+04

  The disk file data will be read, line by line, and ignored until the prescribed data format is satisfied.

- Command line NAMELIST input can be a nuisance. NAMELIST entries begin in column 2 with either a $ or & sign followed immediately with the NAMELIST name. The entries continue with the name of the variables to be changed from their current values, an equal sign, and the new value to be assigned to the variable. The NAMELIST entry must then end with either a $ or & sign. The FORTRAN subroutines NDRUS and NDWUS, as given in Appendix C, were included in the LSPRWC code to simplify this process.

  If a NAMELIST input is requested, then all variables are written to the terminal window with default values to facilitate cut and paste input using a three-button mouse.

  The starting column for NAMELIST entries is irrelevant.

  NAMELIST entries need not begin with the $ or & sign nor is the NAMELIST name required.

  The NAMELIST entry must end with either the $ or & signs but only if variable values are altered. A simple keyboard return will accomplish a NAMELIST entry with no changes to the variable default values.

- Whenever FORTRAN statements include an option for redirection following an error, e.g.

```
READ(UNIT=4,NML=PARM,ERR=169),
```

  and the source of the error is trivial, for example a misspelled NAMELIST variable name, then provision is included in the LSPRWC code for correction of the error without the need to restart.

IV. PROGRAM STRUCTURE

The structure of the LSPRWC FORTRAN 77 computer code as listed in Appendix B is reasonably straight forward. The program routines and their purposes are as follows:

MAIN—Executive control for program LSPRWC

XYDIS—Subroutine for input of the (x, y) data set or observations

CDS—Subroutine for input of the constraints

PODS—Subroutine for input of the polynomial order

LSPRWC—Subroutine to perform the least squares polynomial regression with constraints

XDPEDS—Subroutine to provide an x-coordinate set for evaluation of the least squares regression polynomial

PES—Polynomial evaluation subroutine

QPS—Quick plot subroutine

FDFOS—Formatted disk file output subroutine

GJEMPS—Matrix inversion subroutine using Gauss-Jordan elimination with maximum pivot strategy

POWER—Subroutine to calculate integer powers of real numbers

FACTRL—Factorial evaluation subroutine

As can be seen, the actual least squares polynomial regression algorithm resides in subroutine LSPRWC. Subroutines CDS, PODS, XDPEDS, and XYDIS provide or define input information for program LSPRWC. Subroutine PES provides output data for program LSPRWC. Subroutines FDFOS and QPS output information from program LSPRWC. Subroutines FACTRL, GJEMPS, and POWER are computational utility routines. A flow path for program LSPRWC is given in Figure 1.

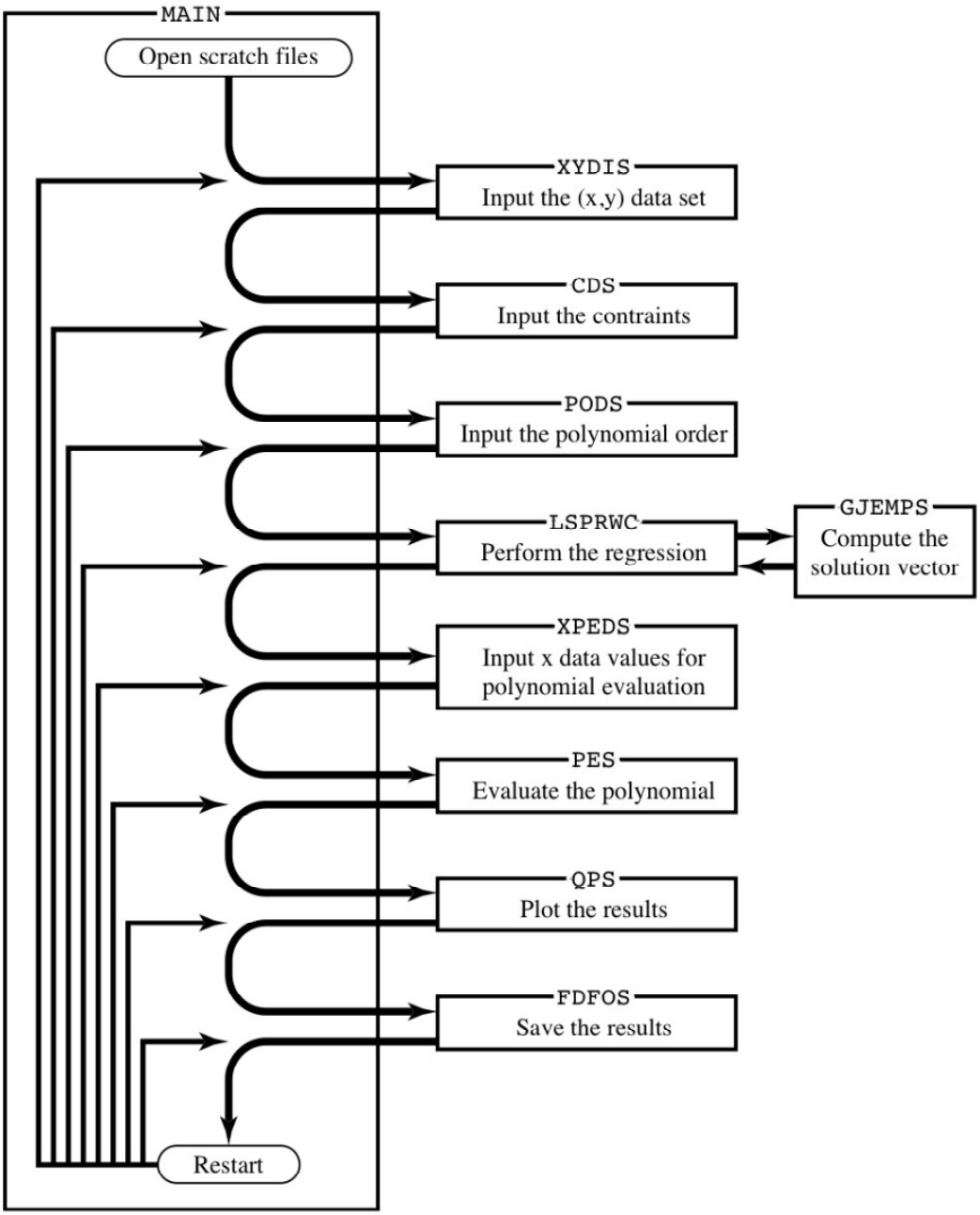

Figure 1. Flow Path for Program LSPRWC

Additional low-level utility routines are listed in the FORTRAN Tool Library in Appendix C.

V. LIMITATIONS

The LSPRWC code has the following requirements or limitations:

- The LSPRWC code was written with the following set of COMMON and PARAMETER statements which set the array sizes consistently in all subroutines.

MNXYDP = Maximum Number of (x, y) Data Pairs

= 101

MNXCE = Maximum Number of x-Coordinates for polynomial evaluation

= 101

MXANC = Maximum Number of Allowable Constraints

= 20

MXNR = Maximum Number of Rows

= 30

MXNRM1 = Maximum Number of Rows minus 1

= 29

MXNC = Maximum Number of Columns

= 31

MXNCM1 = Maximum Number of Columns minus 1

= 30

The number of rows and columns refers to the size of the augmented matrix for the solution of n linear equations in n unknowns. It follows from the derivation of Appendix A that

$$\text{MXNR} \geq n_p + \xi + 1, \tag{1}$$

$$\text{MXNRM1} = \text{MXNR} - 1, \tag{2}$$

$$\text{MXNC} = \text{MXNR} + 1, \text{ and} \tag{3}$$

$$\text{MXNCM1} = \text{MXNC} - 1. \tag{4}$$

The PARAMETER variables MXANC and MXNR apply only for NAMELIST input. Any number of (x, y) data pairs or x-coordinates for polynomial evaluation can be read from disk files.

- The set of (x, y) data pairs, as read into program LSPRWC, must be monotonically increasing in x. Provision could have been made within program LSPRWC to reorder any set of (x, y) data pairs; however, it has been discovered that the failure of a data set to satisfy this requirement is often the indication of unknown errors. Hence, no data set reordering has been implemented.

- The number of (x, y) data pairs or observations, m, must satisfy

$$m \geq n_p + \xi + 1 \ . \tag{5}$$

- The polynomial order n_p must satisfy

$$0 \leq n_p \leq 9 \ . \tag{6}$$

  The LSPRWC code could, though not readily, be modified for polynomial orders greater than 9; however, this largely defeats the purpose intended for polynomial regression.

- The constraint order n_c must satisfy

$$0 \leq n_c < n_p \ . \tag{7}$$

- Polynomials $P(x)$ will not produce an infinite slope. Hence, a transformation—possibly a rotation—may be required for a given set of (x, y) data pairs before a least squares polynomial regression can be completed to eliminate that possibility.

VI. ERROR MESSAGES

The LSPRWC code was written with the following extensive embedded error messaging:

- The error messages cover the standard FORTRAN errors and those associated directly with the operation of program LSPRWC.

- Wherever possible, the LSPRWC code identifies the source of the particular error and the subroutine call structure leading to that error.

- Should readily correctable errors occur, for example a misspelled NAMELIST variable name entry, then program LSPRWC will identify the error and loop, in this case for the NAMELIST entry.

- The standard FORTRAN errors source from the FORTRAN OPEN, CLOSE, READ, and WRITE commands.

- Program LSPRWC will issue an error message should the array limits be exceeded. (See Section V.)

- Program LSPRWC will issue an error message should an illegal value for n_p be entered. (See Section V.)

- Program LSPRWC will issue an error message should an illegal value for n_c be entered. (See Section V.)

- Program LSPRWC will issue an error message should the number of (x, y) data pairs be insufficient for the number of constraints, ξ, and the polynomial order, n_p. (See Section V.)

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APPENDIX A
DERIVATION

A set of (x,y) data pairs are to be "curve fit" using the method of least squares; that is, an n_p order polynomial is chosen such that the sum of the squared errors is minimized over the set of (x,y) data pairs. In addition, the n_p order polynomial must satisfy a set of constraints; namely, that the n_c polynomial derivative be specified at a given *x* location.

Then with the n_p order polynomial given by

$$P(x) = \sum_{j=0}^{n_p} b_j x^j, \tag{1}$$

the squared error to be minimized is

$$S = \sum_{i=1}^{m} [y_i - P(x_i)]^2, \tag{2}$$

$$= \sum_{i=1}^{m} (y_i - \sum_{j=0}^{n_p} b_j x_i^j)^2, \tag{3}$$

subject to the constraints

$$G_l(x_l) = P^{k_l}(x_l) = C_l \tag{4}$$

$$= \sum_{j=k_l}^{n_p} \frac{j!}{(j-k_l)!} b_j x_l^{j-k} = C_l, \tag{5}$$

$$\text{for } \; l = 1,2,3,\cdots,\xi$$

where

n_p = polynomial order,
ξ = number of constraints,
m = number of (x,y) data pairs,
x_l = l_{th} constraint location,
k_l = l_{th} constraint order $(0 \le k_l \le n_p)$,
C_l = value of the l_{th} constraint.

Using the method of undetermined Lagrange multipliers, the relation to be minimized is

$$S^* = S + \sum_{l=1}^{\xi} \lambda_l G_l \tag{6}$$

by setting

$$\frac{\partial S^*}{\partial b_j} = 0 \quad \text{for} = 0, 1, \cdots, n_p. \tag{7}$$

From equations (3), (5), and (6),

$$S^* = \sum_{i=1}^{m} (y_i - \sum_{j=0}^{n_p} b_j x_i^j)^2 + \sum_{l=1}^{\xi} \lambda_l \sum_{j=k_l}^{n_p} \frac{j!}{(j-k_l)!} b_j x_l^{j-k_l}. \tag{8}$$

Then using equation (7),

$$\frac{\partial S^*}{\partial b_J} = \sum_{i=1}^{m} (-2x_i^J)(y_i - \sum_{j=0}^{n_p} b_j x_i^j) + \sum_{l=1}^{\xi} \lambda_l F_{l,J} = 0 \tag{9}$$

where

$$F_{l,J} = \begin{cases} \frac{J!}{(J-k_l)!} x_l^{J-k_l} & , J \geq k_l \\ 0 & , J < k_l \end{cases}. \tag{10}$$

Rewriting equation (9) gives

$$\sum_{i=1}^{m} \sum_{j=0}^{n_p} b_j x_i^{J=j} + \frac{1}{2} \sum_{l=1}^{\xi} \lambda_l F_{l,J} = \sum_{i=1}^{m} y_i x_i^J \tag{11}$$

$$\text{for } J = 0, 1, \cdots, n_p.$$

The minimization equation (11) provides $n_p + 1$ equations in the $n_p + 1$ unknown coefficients b_j and ξ unknown Lagrange multipliers λ_l. Constraint equation (5) provides the remaining ξ equations in the unknown b_j. Since equations (5) and (11) are linear and algebraic, they may be solved simultaneously using a matrix inversion technique.

APPENDIX B
FORTRAN 77 CODE

```
C*********************************************************************00000001
C*                                                                    *00000002
C*    LEAST SQUARES POLYNOMIAL REGRESSION WITH CONSTRAINTS (LSPRWC)   *00000003
C*                                                                    *00000004
C*                       WRITTEN BY: C.D. MIKKELSEN                   *00000005
C*                                                                    *00000006
C*                              2 MAY 1988                            *00000007
C*                                                                    *00000008
C*           AERODYNAMICS TECHNOLOGY BRANCH (AMSMI-RD-SS-AT)          *00000009
C*            SYSTEMS SIMULATION AND DEVELOPMENT DIRECTORATE          *00000010
C*    US ARMY MISSILE RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER   *00000011
C*                      US ARMY MISSILE COMMAND                       *00000012
C*                 REDSTONE ARSENAL, ALABAMA 35898-5252               *00000013
C*                                                                    *00000014
C* REF: CARNAHAN,B., LUTHER, H.A., AND WILKES, J.O.: APPLIED NUMERICAL *00000015
C*      METHODS, NEW YORK, JOHN WILEY & SONS, 1969, PP. 571-584.      *00000016
C*                                                                    *00000017
C*      WEINSTOCK, R.: CALCULUS OF VARIATIONS WITH APPLICATIONS TO    *00000018
C*      PHYSICS AND ENGINEERING, NEW YORK, DOVER PUBLICATIONS, INC.,  *00000019
C*      1974, P. 6.                                                   *00000020
C*                                                                    *00000021
C*                     REVISION DATE: 7 JULY 2011                     *00000022
C*                                                                    *00000023
C*********************************************************************00000024
C                                                                      00000025
C*********************************************************************00000026
C*                                                                    *00000027
C*         PROGRAM LSPRWC REQUIRES THE FOLLOWING SUBPROGRAMS:         *00000028
C*                                                                    *00000029
C*             CBUS06 CDS DFCUS FACTRL FDFOS GJEMPS LSPRWC            *00000030
C*             PES  PODS  POWER  QPS  XDPEDS  XYDIS  YNOUS            *00000031
C*                                                                    *00000032
C*********************************************************************00000033
C                                                                      00000034
C*********************************************************************00000035
C*                                                                    *00000036
C* PARAMETERS:                                                        *00000037
C*                                                                    *00000038
C* MXNRM1 = MAXIMUM NUMBER OF ROWS MINUS 1 (MXNRM1 = MXNR - 1)        *00000039
C*                                                                    *00000040
C* LOGICAL UNIT DEFINITIONS:                                          *00000041
C*                                                                    *00000042
C* UNIT FILE                                                          *00000043
C*                                                                    *00000044
C*   1  INPUT (X,Y) DATA PAIR SCRATCH FILE                            *00000045
C*   2  (XC,NC,CV) CONSTRAINT SCRATCH FILE                            *00000046
C*   3  EVALUATED DATA SCRATCH FILE                                   *00000047
C*   4  TEMPORARY USE                                                 *00000048
C*   5  STANDARD INPUT                                                *00000049
C*   6  STANDARD OUTPUT                                               *00000050
C*                                                                    *00000051
C*********************************************************************00000052
C                                                                      00000053
C                                                                      00000054
      PROGRAM MAIN                                                     00000055
C                                                                      00000056
      IMPLICIT REAL*8(A-H,O-Z)                                         00000057
C                                                                      00000058
      CHARACTER CCV*1                                                  00000059
C                                                                      00000060
```

```
      INTEGER DUM2                                                      00000061
C                                                                       00000062
      PARAMETER (MXNRM1=29)                                             00000063
C                                                                       00000064
      COMMON/B/B(0:MXNRM1)                                              00000065
      COMMON/NCONST/NCONST                                              00000066
      COMMON/NEVAL/NEVAL                                                00000067
      COMMON/NP/NP                                                      00000068
      COMMON/SDEV/SDEV                                                  00000069
C                                                                       00000070
C                                                                       00000071
C*********************************************************************00000072
C*                                                                    *00000073
C*                      OPEN THE SCRATCH FILES                        *00000074
C*                                                                    *00000075
C*********************************************************************00000076
C                                                                       00000077
C                                                                       00000078
      OPEN(UNIT=1,STATUS='SCRATCH',FORM='UNFORMATTED',ERR=116)          00000079
      OPEN(UNIT=2,STATUS='SCRATCH',FORM='UNFORMATTED',ERR=117)          00000080
      OPEN(UNIT=3,STATUS='SCRATCH',FORM='UNFORMATTED',ERR=118)          00000081
C                                                                       00000082
C                                                                       00000083
C*********************************************************************00000084
C*                                                                    *00000085
C*                   WRITE THE PROGRAM DESCRIPTION                    *00000086
C*                                                                    *00000087
C*********************************************************************00000088
C                                                                       00000089
C                                                                       00000090
      WRITE(UNIT=6,FMT=201)                                             00000091
      WRITE(UNIT=6,FMT=202)                                             00000092
      READ(UNIT=5,FMT=203)CCV                                           00000093
C                                                                       00000094
C                                                                       00000095
C*********************************************************************00000096
C*                                                                    *00000097
C*               INPUT THE X-Y DATA POINTS TO BE FITTED               *00000098
C*                                                                    *00000099
C*********************************************************************00000100
C                                                                       00000101
C                                                                       00000102
101   CALL XYDIS(*119,*115)                                             00000103
C                                                                       00000104
C                                                                       00000105
C*********************************************************************00000106
C*                                                                    *00000107
C*                       INPUT THE CONSTRAINTS                        *00000108
C*                                                                    *00000109
C*********************************************************************00000110
C                                                                       00000111
C                                                                       00000112
102   NCONST=0                                                          00000113
103   WRITE(UNIT=6,FMT=208)                                             00000114
      CALL YNOUS(*104,*105,*103)                                        00000115
104   CALL CDS(*120,*115)                                               00000116
C                                                                       00000117
C                                                                       00000118
C*********************************************************************00000119
C*                                                                    *00000120
```

```
C*                    INPUT THE POLYNOMIAL ORDER                      *00000121
C*                                                                    *00000122
C**********************************************************************00000123
C                                                                       00000124
C                                                                       00000125
105   CALL PODS(*115)                                                   00000126
C                                                                       00000127
C                                                                       00000128
C**********************************************************************00000129
C*                                                                    *00000130
C*  PERFORM THE LEAST SQUARES POLYNOMIAL REGRESSION WITH CONSTRAINTS   *00000131
C*                                                                    *00000132
C**********************************************************************00000133
C                                                                       00000134
C                                                                       00000135
      CALL LSPRWC(*121)                                                 00000136
      WRITE(UNIT=6,FMT=209)                                             00000137
      WRITE(UNIT=6,FMT=210)(I,B(I),I=0,NP)                              00000138
      WRITE(UNIT=6,FMT=211)NP,SDEV                                      00000139
      WRITE(UNIT=6,FMT=202)                                             00000140
      READ(UNIT=5,FMT=203)CCV                                           00000141
C                                                                       00000142
C                                                                       00000143
C**********************************************************************00000144
C*                                                                    *00000145
C*                INPUT THE X DATA POINTS FOR EVALUATION              *00000146
C*                   OF THE LEAST SQUARES POLYNOMIAL                  *00000147
C*                                                                    *00000148
C**********************************************************************00000149
C                                                                       00000150
C                                                                       00000151
106   WRITE(UNIT=6,FMT=212)                                             00000152
      LCV2=0                                                            00000153
      CALL YNOUS(*107,*112,*106)                                        00000154
107   CALL XDPEDS(LCV2,*122,*115)                                       00000155
C                                                                       00000156
C                                                                       00000157
C**********************************************************************00000158
C*                                                                    *00000159
C*  EVALUATE THE LEAST SQUARES POLYNOMIAL AT THE PRESCRIBED X VALUES   *00000160
C*                                                                    *00000161
C**********************************************************************00000162
C                                                                       00000163
C                                                                       00000164
108   CALL PES(*123)                                                    00000165
109   WRITE(UNIT=6,FMT=205)                                             00000166
      CALL YNOUS(*110,*112,*109)                                        00000167
110   REWIND 3                                                          00000168
      WRITE(UNIT=6,FMT=206)                                             00000169
      DO 111 I=1,NEVAL                                                  00000170
      READ(UNIT=3,ERR=124)X,Y                                           00000171
      IF(MOD(I,20).NE.0) GO TO 111                                      00000172
      WRITE(UNIT=6,FMT=202)                                             00000173
      READ(UNIT=5,FMT=203)CCV                                           00000174
      WRITE(UNIT=6,FMT=206)                                             00000175
111   WRITE(UNIT=6,FMT=207)I,X,Y                                        00000176
      WRITE(UNIT=6,FMT=202)                                             00000177
      READ(UNIT=5,FMT=203)CCV                                           00000178
C                                                                       00000179
C                                                                       00000180
```

```
C*************************************************************************00000181
C*                                                                       *00000182
C*                          PLOT THE RESULTS                             *00000183
C*                                                                       *00000184
C*************************************************************************00000185
C                                                                        00000186
C                                                                        00000187
112   WRITE(UNIT=6,FMT=213)                                              00000188
      CALL YNOUS(*113,*115,*112)                                         00000189
113   CALL QPS(*125)                                                     00000190
      GO TO 115                                                          00000191
C                                                                        00000192
C                                                                        00000193
C*************************************************************************00000194
C*                                                                       *00000195
C*                SAVE RESULTS ON FORMATTED DISK FILE                    *00000196
C*                                                                       *00000197
C*************************************************************************00000198
C                                                                        00000199
C                                                                        00000200
114   CALL FDFOS(LCV2,*126)                                              00000201
C                                                                        00000202
C                                                                        00000203
C*************************************************************************00000204
C*                                                                       *00000205
C*                          RESTART PROCEDURE                            *00000206
C*                                                                       *00000207
C*************************************************************************00000208
C                                                                        00000209
C                                                                        00000210
115   WRITE(UNIT=6,FMT=214)                                              00000211
      READ(UNIT=5,FMT=204)LCV1                                           00000212
      GO TO (101,104,105,107,113,114),LCV1                               00000213
      STOP                                                               00000214
C                                                                        00000215
C                                                                        00000216
C*************************************************************************00000217
C*                                                                       *00000218
C*                            ERROR MESSAGES                             *00000219
C*                                                                       *00000220
C*************************************************************************00000221
C                                                                        00000222
C                                                                        00000223
116   WRITE(UNIT=6,FMT=215)                                              00000224
      STOP                                                               00000225
117   WRITE(UNIT=6,FMT=216)                                              00000226
      STOP                                                               00000227
118   WRITE(UNIT=6,FMT=217)                                              00000228
      STOP                                                               00000229
119   WRITE(UNIT=6,FMT=218)                                              00000230
      STOP                                                               00000231
120   WRITE(UNIT=6,FMT=219)                                              00000232
      STOP                                                               00000233
121   WRITE(UNIT=6,FMT=220)                                              00000234
      GO TO 128                                                          00000235
122   WRITE(UNIT=6,FMT=221)                                              00000236
      STOP                                                               00000237
123   WRITE(UNIT=6,FMT=222)                                              00000238
      STOP                                                               00000239
124   WRITE(UNIT=6,FMT=223)                                              00000240
```

```
      STOP                                                              00000241
125   WRITE(UNIT=6,FMT=224)                                             00000242
      STOP                                                              00000243
126   WRITE(UNIT=6,FMT=225)                                             00000244
      STOP                                                              00000245
127   WRITE(UNIT=6,FMT=226)                                             00000246
      STOP                                                              00000247
128   WRITE(UNIT=6,FMT=202)                                             00000248
      READ(UNIT=5,FMT=203)CCV                                           00000249
      GO TO 115                                                         00000250
C                                                                       00000251
C                                                                       00000252
C*********************************************************************00000253
C*                                                                    *00000254
C*                          FORMAT STATEMENTS                         *00000255
C*                                                                    *00000256
C*********************************************************************00000257
C                                                                       00000258
C                                                                       00000259
201    FORMAT(/,T4,'PROGRAM LSPRWC IS AN INTERACTIVE FORTRAN PROGRAM TO P00000260
     >ERFORM A LEAST',/,'SQUARES POLYNOMIAL REGRESSION WITH CONTRAINTS; 00000261
     >THAT IS, A SET OF X-Y DATA',/,'POINTS IS CURVE FIT WITH AN NP ORDE00000262
     >R POLYNOMIAL OF THE FORM',//,T17,'P(X)=B0+B1*X+B2*X**2+B3*X**3+...00000263
     >.+BNP*X**NP',//,'WITH ANY POLYNOMIAL DERIVATIVES, ZERO THROUGH NP,00000264
     > SPECIFIED AT GIVEN X',/,'LOCATIONS.  THE PROCEDURE FOLLOWED IS TH00000265
     >E METHOD OF LEAST SQUARES USING',/,'UNDETERMINED LAGRANGE MULTIPLI00000266
     >ERS.',//,T4,'AS AN INTERACTIVE PROGRAM, LSPRWC IS SELF-EXPLANATORY00000267
     > AND PROMPTS FOR THE',/,'NECESSARY INFORMATION.  THE X-Y DATA TO B00000268
     >E FITTED MAY BE ENTERED BY NAMELIST',/,'OR READ FROM A FORMATTED D00000269
     >ISC FILE.  PROGRAM LSPRWC WILL ALSO EVALUATE THE',/,'RESULTANT LEA00000270
     >ST SQUARES POLYNOMIAL AT PRESCRIBED VALUES OF X WHICH, AGAIN,',/,'00000271
     >MAY BE ENTERED BY NAMELIST OR READ FROM A FORMATTED DISK FILE.')  00000272
202    FORMAT(/,T19,'- ENTER/RETURN TO CONTINUE -')                     00000273
203    FORMAT(A1)                                                       00000274
204    FORMAT(I1)                                                       00000275
205    FORMAT(/,'SHOULD THE X-Y DATA BE DISPLAYED FOR VERIFICATION? (Y/N)00000276
     >')                                                                00000277
206    FORMAT(/,T10,'NO.',T26,'X',T49,'Y')                              00000278
207    FORMAT(T8,I5,1P2D23.13)                                          00000279
208    FORMAT(/,'ARE CONSTRAINTS DESIRED? (Y/N)')                       00000280
209    FORMAT(T7,'LEAST SQUARES POLYNOMIAL',//,T19,'P(X)=B(0)+B(1)*X+B(2)00000281
     >*X**2+....+B(NP)*X**NP',//,T22,'I',T36,'B(I)',/)                  00000282
210    FORMAT(' ',T22,I1,1PD25.13)                                      00000283
211    FORMAT(/,T4,'THE STANDARD DEVIATION FOR THIS POLYNOMIAL OF ORDER  00000284
     > ',I1,' IS ',1PD12.5)                                             00000285
212    FORMAT(/,'SHOULD DATA POINTS BE PRESCRIBED FOR EVALUATION OF THE L00000286
     >EAST SQUARES',/,'POLYNOMIALS? (Y/N)')                             00000287
213    FORMAT(/,'SHOULD THE RESULTS OF THIS RUN BE QUICK-PLOTTED? (Y/N)')00000288
     >                                                                  00000289
214    FORMAT(/,'ENTER:',/,'1, TO RESTART THE PROGRAM',/,'2, TO CHANGE TH00000290
     >E CONSTRAINTS',/,'3, TO CHANGE THE POLYNOMIAL ORDER',/,'4, TO CHAN00000291
     >GE THE PRESCRIBED X VALUES FOR EVALUATION OF THE POLYNOMIAL',/,'5,00000292
     > TO PLOT THE RESULTS',/,'6, TO SAVE THE RESULTS ON A FORMATTED DIS00000293
     >C FILE',/,'7, TO STOP')                                           00000294
215    FORMAT(/,'ERROR IN PROGRAM LSPRWC: OPEN ERROR ON UNIT 1, STATUS = 00000295
     >"SCRATCH"')                                                       00000296
216    FORMAT(/,'ERROR IN PROGRAM LSPRWC: OPEN ERROR ON UNIT 2, STATUS = 00000297
     >"SCRATCH"')                                                       00000298
217    FORMAT(/,'ERROR IN PROGRAM LSPRWC: OPEN ERROR ON UNIT 3, STATUS = 00000299
     >"SCRATCH"')                                                       00000300
```

```
218   FORMAT('SUBROUTINE XYDIS WAS CALLED FROM PROGRAM LSPRWC')          00000301
219   FORMAT('SUBROUTINE CDS WAS CALLED FROM PROGRAM LSPRWC')            00000302
220   FORMAT('SUBROUTINE LSPRWC WAS CALLED FROM PROGRAM LSPRWC')         00000303
221   FORMAT('SUBROUTINE XDPEDS WAS CALLED FROM PROGRAM LSPRWC')         00000304
222   FORMAT('SUBROUTINE PES WAS CALLED FROM PROGRAM LSPRWC')            00000305
223   FORMAT(/,'ERROR IN PROGRAM LSPRWC: UNFORMATTED READ ERROR ON$UNIT 00000306
     >3')                                                               00000307
224   FORMAT('SUBROUTINE QPS WAS CALLED FROM PROGRAM LSPRWC')            00000308
225   FORMAT('SUBROUTINE FDFOS WAS CALLED FROM PROGRAM LSPRWC')          00000309
226   FORMAT('SUBROUTINE CBUS06 WAS CALLED FROM PROGRAM LSPRWC')         00000310
      END                                                                00000311
```

```
      SUBROUTINE CDS(*,*)                                                00000001
C                                                                        00000002
C                                                                        00000003
C*************************************************************************00000004
C*                                                                       *00000005
C*               CONSTRAINT DEFINITION SUBROUTINE (CDS)                  *00000006
C*                                                                       *00000007
C*                     REVISION DATE: 1 JULY 2011                        *00000008
C*                                                                       *00000009
C*************************************************************************00000010
C                                                                        00000011
C*************************************************************************00000012
C*                                                                       *00000013
C*       SUBROUTINE CDS DEFINES CONSTRAINTS FOR PROGRAM LSPRWC.          *00000014
C*                                                                       *00000015
C* INPUT/OUTPUT VARIABLES:                                               *00000016
C*                                                                       *00000017
C* CV     = VALUE OF THE NC-TH DERIVATIVE FOR THE CONSTRAINT AT XC       *00000018
C* NC     = CONSTRAINT ORDER                                             *00000019
C* NCONST = NUMBER OF CONSTRAINTS                                        *00000020
C* XC     = X-VALUE FOR THE CONSTRAINT                                   *00000021
C*                                                                       *00000022
C* PARAMETERS:                                                           *00000023
C*                                                                       *00000024
C* MXNAC  = MAXIMUM NUMBER OF ALLOWABLE CONSTRAINTS                      *00000025
C*                                                                       *00000026
C*************************************************************************00000027
C                                                                        00000028
C                                                                        00000029
      IMPLICIT REAL*8(A-H,O-Z)                                           00000030
C                                                                        00000031
      CHARACTER CCV*1,DFmt*3,File*80,Fmt*80                              00000032
C                                                                        00000033
      INTEGER DUM2                                                       00000034
C                                                                        00000035
      PARAMETER (R_NaN=-999.E+00)                                        00000036
      PARAMETER (MXNAC=20)                                               00000037
C                                                                        00000038
      COMMON/CV/CV(MXNAC)                                                00000039
      COMMON/NC/NC(MXNAC)                                                00000040
      COMMON/NCONST/NCONST                                               00000041
      COMMON/XC/XC(MXNAC)                                                00000042
C                                                                        00000043
      DATA DFmt/'(*)'/                                                   00000044
C                                                                        00000045
      NAMELIST/PARM/CV,NC,XC                                             00000046
C                                                                        00000047
C                                                                        00000048
C*************************************************************************00000049
C*                                                                       *00000050
C*                        INPUT THE CONSTRAINTS                          *00000051
C*                                                                       *00000052
C*************************************************************************00000053
C                                                                        00000054
C                                                                        00000055
      DO 101 I=1,MXNAC                                                   00000056
      CV(I)=R_NaN                                                        00000057
      NC(I)=-1                                                           00000058
101   XC(I)=R_NaN                                                        00000059
      WRITE(UNIT=6,FMT=201)                                              00000060
```

```
      READ(UNIT=5,FMT=202)LCV1                                          00000061
      IF(LCV1.EQ.2) GO TO 104                                           00000062
C                                                                       00000063
102   WRITE(UNIT=6,FMT=203)MXNAC                                        00000064
      WRITE(UNIT=6,FMT=204)                                             00000065
      CALL NDRUS('PARM',4,*102,*121)                                    00000066
      READ(UNIT=4,NML=PARM,ERR=102)                                     00000067
      CALL NDRUSE(*102,*121)                                            00000068
      DO 103 NCONST=MXNAC,1,-1                                          00000069
      IF(XC(NCONST).NE.R_NaN) GO TO 111                                 00000070
103   CONTINUE                                                          00000071
      GO TO 111                                                         00000072
C                                                                       00000073
104   WRITE(UNIT=6,FMT=205)MXNAC                                        00000074
      WRITE(UNIT=6,FMT=206)                                             00000075
      READ(UNIT=5,FMT=207)FILE                                          00000076
105   WRITE(UNIT=6,FMT=208)                                             00000077
      WRITE(UNIT=6,FMT=209)                                             00000078
      CALL DFCUS(Fmt,DFmt,*105)                                         00000079
      OPEN(UNIT=4,FILE=File,STATUS='OLD',ERR=122)                       00000080
      REWIND 4                                                          00000081
      IF(Fmt(1:3).EQ.DFmt) GO TO 107                                    00000082
      DO 106 NCONST=1,MXNAC                                             00000083
106   READ(UNIT=4,FMT=Fmt,END=109,ERR=123)XC(NCONST),NC(NCONST),        00000084
     >CV(NCONST)                                                        00000085
      GO TO 110                                                         00000086
107   DO 108 NCONST=1,MXNAC                                             00000087
108   READ(UNIT=4,FMT=*,END=109,ERR=123)XC(NCONST),NC(NCONST),CV(NCONST)00000088
      GO TO 110                                                         00000089
109   NCONST=NCONST-1                                                   00000090
110   CLOSE(UNIT=4,STATUS='KEEP',ERR=124)                               00000091
C                                                                       00000092
C                                                                       00000093
C***********************************************************************00000094
C*                                                                     *00000095
C*                    SORT AND EDIT THE CONSTRAINTS                    *00000096
C*                                                                     *00000097
C***********************************************************************00000098
C                                                                       00000099
C                                                                       00000100
111   IF(NCONST.EQ.0) GO TO 120                                         00000101
      IF(NCONST.EQ.1) GO TO 117                                         00000102
      DO 112 I=1,NCONST-1                                               00000103
      DO 112 J=I+1,NCONST                                               00000104
      IF(XC(I).NE.XC(J)) GO TO 112                                      00000105
      IF(NC(I).NE.NC(J)) GO TO 112                                      00000106
      XC(I)=R_NaN                                                       00000107
112   CONTINUE                                                          00000108
113   LCV1=0                                                            00000109
      DO 115 I=2,NCONST                                                 00000110
      IF(XC(I-1).LT.XC(I)) GO TO 115                                    00000111
      IF(XC(I-1).GT.XC(I)) GO TO 114                                    00000112
      IF(NC(I-1).LT.NC(I)) GO TO 115                                    00000113
114   LCV1=1                                                            00000114
      DUM1=XC(I-1)                                                      00000115
      DUM2=NC(I-1)                                                      00000116
      DUM3=CV(I-1)                                                      00000117
      XC(I-1)=XC(I)                                                     00000118
      NC(I-1)=NC(I)                                                     00000119
      CV(I-1)=CV(I)                                                     00000120
```

```
      XC(I)=DUM1                                                        00000121
      NC(I)=DUM2                                                        00000122
      CV(I)=DUM3                                                        00000123
115   CONTINUE                                                          00000124
      IF(LCV1.EQ.1) GO TO 113                                           00000125
      DO 116 NCONST=MXNAC,1,-1                                          00000126
      IF(XC(NCONST).NE.R_NaN) GO TO 117                                 00000127
116   CONTINUE                                                          00000128
C                                                                       00000129
117   WRITE(UNIT=6,FMT=210)                                             00000130
      CALL YNOUS(*118,*120,*117)                                        00000131
118   WRITE(UNIT=6,FMT=211)                                             00000132
      DO 119 I=1,NCONST                                                 00000133
      IF(MOD(I,20).NE.0) GO TO 119                                      00000134
      WRITE(UNIT=6,FMT=212)                                             00000135
      READ(UNIT=5,FMT=213)CCV                                           00000136
      WRITE(UNIT=6,FMT=211)                                             00000137
119   WRITE(UNIT=6,FMT=214)I,XC(I),NC(I),CV(I)                          00000138
      WRITE(UNIT=6,FMT=212)                                             00000139
      READ(UNIT=5,FMT=213)CCV                                           00000140
120   RETURN                                                            00000141
C                                                                       00000142
C                                                                       00000143
C*********************************************************************00000144
C*                                                                   *00000145
C*                          ERROR MESSAGES                           *00000146
C*                                                                   *00000147
C*********************************************************************00000148
C                                                                       00000149
C                                                                       00000150
121   WRITE(UNIT=6,FMT=215)                                             00000151
      GO TO 126                                                         00000152
122   WRITE(UNIT=6,FMT=216)                                             00000153
      CALL CBUS06(6,File,*125)                                          00000154
      RETURN 1                                                          00000155
123   WRITE(UNIT=6,FMT=217)                                             00000156
      CALL CBUS06(6,File,*125)                                          00000157
      RETURN 1                                                          00000158
124   WRITE(UNIT=6,FMT=218)                                             00000159
      CALL CBUS06(6,File,*125)                                          00000160
      RETURN 1                                                          00000161
125   WRITE(UNIT=6,FMT=219)                                             00000162
      RETURN 1                                                          00000163
126   WRITE(UNIT=6,FMT=212)                                             00000164
      READ(UNIT=5,FMT=213)CCV                                           00000165
      RETURN 2                                                          00000166
C                                                                       00000167
C                                                                       00000168
C*********************************************************************00000169
C*                                                                   *00000170
C*                        FORMAT STATEMENTS                          *00000171
C*                                                                   *00000172
C*********************************************************************00000173
C                                                                       00000174
C                                                                       00000175
201   FORMAT(/,'SELECT THE SOURCE OF INPUT FOR THE CONSTRAINTS FROM THE 00000176
     >FOLLOWING LIST:',//,'1, FOR KEYBOARD INPUT VIA NAMELIST',/,'2, FOR00000177
     > FORMATTED DISK FILE INPUT',//,'NOTE: THE CONSTRAINTS ARE COMPLETE00000178
     >LY INDEPENDENT OF THE X-Y DATA POINTS TO BE',/,'FITTED.')         00000179
202   FORMAT(I1)                                                        00000180
```

```
203   FORMAT(/,'INPUT THE CONSTRAINTS (',I2,' MAX) BY NAMELIST WHERE:',/00000181
     >/,'CV     = ARRAY OF POLYNOMIAL DERIVATIVE VALUES',/,'NC     = ARR00000182
     >AY OF POLYNOMIAL DERIVATIVE ORDERS (CONSTRAINT ORDER)',/,'XC     =00000183
     > ARRAY OF POLYNOMIAL DERIVATIVE LOCATIONS (CONSTRAINT X VALUES)',/00000184
     >/,'NOTE: NC VALUES MUST BE IN THE RANGE 0 TO NP.',//,T2,'CURRENT V00000185
     >ALUES ARE:')                                                      00000186
204   FORMAT(/,'$PARM CV=____,____,____,NC=____,____,____,XC=____,____,_00000187
     >___$',/)                                                          00000188
205   FORMAT(/,'CONSTRAINTS (',I2,' MAX) ARE INPUT FROM FORMATTED DISK F00000189
     >ILES AS (XC,NC,CV) TRIPLES',/,'WHERE:',//,'CV     = POLYNOMIAL DER00000190
     >IVATIVE VALUE',/,'NC     = POLYNOMIAL DERIVATIVE OR CONSTRAINT ORD00000191
     >ER',/,'XC     = POLYNOMIAL DERIVATIVE LOCATION (CONSTRAINT X VALUE00000192
     >)',//,'NOTE: NC VALUES MUST BE IN THE RANGE 0 TO NP.')            00000193
206   FORMAT(/,'INPUT THE FILE NAME OF THE FORMATTED DISK FILE DATA SET.00000194
     >')                                                                00000195
207   FORMAT(A80)                                                       00000196
208   FORMAT(/,'INPUT THE DATA FILE FORMAT (INCLUDE PARENTHESES)')      00000197
209   FORMAT('NOTE: AN EXAMPLE FORMAT IS "(2E15.6)"',/,T7,'ENTER"(*)" FO00000198
     >R A FREE FIELD READ (DEFAULT FORMAT)')                            00000199
210   FORMAT(/,'SHOULD THE CONSTRAINTS BE DISPLAYED FOR VERIFICATION? (Y00000200
     >/N)')                                                             00000201
211   FORMAT(/,T6,'NO.',T27,'XC(I)',T35,'NC(I)',T58,'CV(I)')            00000202
212   FORMAT(/,T19,'- ENTER/RETURN TO CONTINUE -')                      00000203
213   FORMAT(A1)                                                        00000204
214   FORMAT(T8,I3,1PD23.13,I7,D23.13)                                  00000205
215   FORMAT('SUBROUTINE NDRUS WAS CALLED FROM PROGRAM LSPRWC')         00000206
216   FORMAT(/,'ERROR IN PROGRAM LSPRWC: OPEN ERROR ON UNIT 4, STATUS = 00000207
     >"OLD", FILE =',/)                                                 00000208
217   FORMAT(/,'ERROR IN PROGRAM LSPRWC: READ ERROR ON UNIT 4, FILE =',/00000209
     >)                                                                 00000210
218   FORMAT(/,'ERROR IN PROGRAM LSPRWC: CLOSE ERROR ON UNIT 4, FILE =',00000211
     >/)                                                                00000212
219   FORMAT('SUBROUTINE CBUS06 WAS CALLED FROM PROGRAM LSPRWC')        00000213
      END                                                               00000214
```

```
      FUNCTION FACTRL(N)                                                00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*          FACTORIAL EVALUATION FUNCTION SUBPROGRAM (FACTRL)          *00000006
C*                                                                     *00000007
C*                     REVISION DATE: 15 JUNE 1989                     *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C                                                                       00000012
      INTEGER FACTRL                                                    00000013
      FACTRL=1                                                          00000014
      IF(N.LE.1) RETURN                                                 00000015
      DO 101 I=0,N-1                                                    00000016
101   FACTRL=FACTRL*(N-I)                                               00000017
      END                                                               00000018
```

```
      SUBROUTINE FDFOS(LCV2,*)                                          00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*            FORMATTED DISK FILE OUTPUT SUBROUTINE (FDFOS)            *00000006
C*                                                                     *00000007
C*                     REVISION DATE: 2 OCTOBER 2007                   *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C***********************************************************************00000012
C*                                                                     *00000013
C* PARAMETERS:                                                         *00000014
C*                                                                     *00000015
C* MXANC  = MAXIMUM NUMBER OF ALLOWABLE CONSTRAINTS                    *00000016
C* MXNR   = MAXIMUM NUMBER OF ROWS                                     *00000017
C* MXNRM1 = MAXIMUM NUMBER OF ROWS MINUS 1 (MXNRM1 = MXNR - 1)         *00000018
C*                                                                     *00000019
C***********************************************************************00000020
C                                                                       00000021
C                                                                       00000022
      IMPLICIT REAL*8(A-H,O-Z)                                          00000023
C                                                                       00000024
      CHARACTER Alist*1,Blank*1,DFmt*9,File*80,Fmt*80,SList*1           00000025
C                                                                       00000026
      PARAMETER (MXANC=20,MXNRM1=29)                                    00000027
C                                                                       00000028
      COMMON/B/B(0:MXNRM1)                                              00000029
      COMMON/CV/CV(MXANC)                                               00000030
      COMMON/NC/NC(MXANC)                                               00000031
      COMMON/NCONST/NCONST                                              00000032
      COMMON/NDATA/NDATA                                                00000033
      COMMON/NEVAL/NEVAL                                                00000034
      COMMON/NP/NP                                                      00000035
      COMMON/SDEV/SDEV                                                  00000036
      COMMON/XC/XC(MXANC)                                               00000037
C                                                                       00000038
      DIMENSION AList(13),NList(13),SList(-1:11),YK(-1:11)              00000039
C                                                                       00000040
      SAVE Blank,DFmt                                                   00000041
C                                                                       00000042
      DATA Blank/' '/,DFmt/'(13E15.6)'/,SList/"X","0","1","2","3","4",  00000043
     >"5","6","7","8","9","R","S"/                                      00000044
C                                                                       00000045
      NAMELIST/PARM/AList                                               00000046
C                                                                       00000047
C                                                                       00000048
C***********************************************************************00000049
C*                                                                     *00000050
C*                       SELECT AN OUTPUT OPTION                       *00000051
C*                                                                     *00000052
C***********************************************************************00000053
C                                                                       00000054
C                                                                       00000055
      WRITE(UNIT=6,FMT=201)                                             00000056
      READ(UNIT=5,FMT=202)FILE                                          00000057
      WRITE(UNIT=6,FMT=203)                                             00000058
      READ(UNIT=5,FMT=204)LCV1                                          00000059
      IF(LCV1.EQ.2.AND.LCV2.EQ.0) GO TO 113                             00000060
```

```
      OPEN(UNIT=4,FILE=File,FORM='FORMATTED',STATUS='UNKNOWN',ERR=114)  00000061
      REWIND 4                                                         00000062
      IF(LCV1.EQ.2) GO TO 104                                          00000063
C                                                                      00000064
C                                                                      00000065
C**********************************************************************00000066
C*                                                                    *00000067
C*                  OUTPUT ALL INPUT DATA AND RESULTS                 *00000068
C*                                                                    *00000069
C**********************************************************************00000070
C                                                                      00000071
C                                                                      00000072
      WRITE(UNIT=4,FMT=205,ERR=115)                                    00000073
      WRITE(UNIT=4,FMT=206,ERR=115)                                    00000074
      REWIND 1                                                         00000075
      DO 101 I=1,NDATA                                                 00000076
      READ(UNIT=1,ERR=116)X,Y                                          00000077
101   WRITE(UNIT=4,FMT=207,ERR=115)I,X,Y                               00000078
      IF(NCONST.EQ.0) GO TO 102                                        00000079
      WRITE(UNIT=4,FMT=208,ERR=115)                                    00000080
      WRITE(UNIT=4,FMT=209,ERR=115)(I,XC(I),NC(I),CV(I),I=1,NCONST)    00000081
102   WRITE(UNIT=4,FMT=210,ERR=115)                                    00000082
      WRITE(UNIT=4,FMT=211,ERR=115)(I,B(I),I=0,NP)                     00000083
      WRITE(UNIT=4,FMT=212,ERR=115)NP,SDEV                             00000084
      IF(LCV2.EQ.0) GO TO 112                                          00000085
      WRITE(UNIT=4,FMT=213,ERR=115)                                    00000086
      REWIND 3                                                         00000087
      DO 103 I=1,NEVAL                                                 00000088
      READ(UNIT=3,ERR=117)X,Y                                          00000089
103   WRITE(UNIT=4,FMT=207,ERR=115)I,X,Y                               00000090
      GO TO 112                                                        00000091
C                                                                      00000092
C                                                                      00000093
C**********************************************************************00000094
C*                                                                    *00000095
C*                   OUTPUT ONLY THE EVALUATED DATA                   *00000096
C*                                                                    *00000097
C**********************************************************************00000098
C                                                                      00000099
C                                                                      00000100
104   DO 105 K=3,13                                                    00000101
      AList(K)=Blank                                                   00000102
105   NList(K)=-999                                                    00000103
      AList(1)='X'                                                     00000104
      AList(2)='0'                                                     00000105
      WRITE(UNIT=6,FMT=214)SList(-1)                                   00000106
      WRITE(UNIT=6,FMT=215)(SList(K),K,K=0,NP)                         00000107
      WRITE(UNIT=6,FMT=216)(SList(K),K=10,11)                          00000108
      WRITE(UNIT=6,FMT=217)                                            00000109
      CALL NDRUS('PARM',9,*104,*118)                                   00000110
      READ(UNIT=9,NML=PARM,ERR=104)                                    00000111
      CALL NDRUSE(*104,*118)                                           00000112
      DO 106 NL=1,13                                                   00000113
      IF(AList(NL).EQ.Blank) GO TO 107                                 00000114
106   CONTINUE                                                         00000115
107   NL=NL-1                                                          00000116
      IF(NL.EQ.0) GO TO 119                                            00000117
      DO 110 I=1,NL                                                    00000118
      DO 108 K=-1,11                                                   00000119
      IF(AList(I).EQ.SList(K)) GO TO 109                               00000120
```

```
108   CONTINUE                                                          00000121
      GO TO 120                                                         00000122
109   NList(I)=K                                                        00000123
      IF(K.EQ.10) NList(I)=NP+1                                         00000124
      IF(K.EQ.11) NList(I)=NP+2                                         00000125
      IF(NP.LT.K.AND.K.LT.10) GO TO 120                                 00000126
110   CONTINUE                                                          00000127
C                                                                       00000128
      WRITE(UNIT=6,FMT=218)                                             00000129
      CALL CBUS06(6,DFmt,*122)                                          00000130
      CALL DFCUS(Fmt,DFmt,*104)                                         00000131
      REWIND 3                                                          00000132
      DO 111 I=1,NEVAL                                                  00000133
      READ(UNIT=3,ERR=117)(YK(K),K=-1,NP+2)                             00000134
111   WRITE(UNIT=4,FMT=Fmt,ERR=115)(YK(NList(K)),K=1,NL)                00000135
112   CLOSE(UNIT=4,STATUS='KEEP',ERR=121)                               00000136
      RETURN                                                            00000137
C                                                                       00000138
C                                                                       00000139
C***********************************************************************00000140
C*                                                                     *00000141
C*                          ERROR MESSAGES                             *00000142
C*                                                                     *00000143
C***********************************************************************00000144
C                                                                       00000145
C                                                                       00000146
113   WRITE(UNIT=6,FMT=219)                                             00000147
      CALL CBUS06(6,File,*122)                                          00000148
      WRITE(UNIT=6,FMT=220)                                             00000149
      RETURN                                                            00000150
114   WRITE(UNIT=6,FMT=221)                                             00000151
      CALL CBUS06(6,File,*122)                                          00000152
      RETURN 1                                                          00000153
115   WRITE(UNIT=6,FMT=222)                                             00000154
      CALL CBUS06(6,File,*122)                                          00000155
      RETURN 1                                                          00000156
116   WRITE(UNIT=6,FMT=223)                                             00000157
      RETURN 1                                                          00000158
117   WRITE(UNIT=6,FMT=224)                                             00000159
      RETURN 1                                                          00000160
118   WRITE(UNIT=6,FMT=225)                                             00000161
      RETURN 1                                                          00000162
119   WRITE(UNIT=6,FMT=226)                                             00000163
      GO TO 104                                                         00000164
120   WRITE(UNIT=6,FMT=227)I,AList(I)                                   00000165
      GO TO 104                                                         00000166
121   WRITE(UNIT=6,FMT=228)                                             00000167
      CALL CBUS06(6,File,*122)                                          00000168
      RETURN 1                                                          00000169
122   WRITE(UNIT=6,FMT=229)                                             00000170
      RETURN 1                                                          00000171
C                                                                       00000172
C                                                                       00000173
C***********************************************************************00000174
C*                                                                     *00000175
C*                        FORMAT STATEMENTS                            *00000176
C*                                                                     *00000177
C***********************************************************************00000178
C                                                                       00000179
C                                                                       00000180
```

```
201   FORMAT(/,'INPUT THE FILE NAME OF THE FORMATTED DISK FILE.')       00000181
202   FORMAT(A80)                                                       00000182
203   FORMAT(/,'SELECT THE TYPE OF OUTPUT FOR THE FORMATTED DISK FILE FR00000183
     >OM THE FOLLOWING LIST:',/,'1, FOR ALL INPUT DATA AND RESULTS',/,'200000184
     >, FOR ONLY THE EVALUATED DATA')                                  00000185
204   FORMAT(I1)                                                        00000186
205   FORMAT(T6,'LEAST SQUARES POLYNOMIAL REGRESSION WITH CONSTRAINTS (L00000187
     >SPRWC)',//,T22,'WRITTEN BY: C.D. MIKKELSEN',//,T31,'2 MAY 1988',//00000188
     >,T13,'AERODYNAMICS TECHNOLOGY BRANCH (AMSMI-RD-SS-AT)',/,T13,'SYST00000189
     >EMS SIMULATION AND DEVELOPMENT DIRECTORATE',/,T6,'US ARMY MISSILE 00000190
     >RESEARCH, ENGINEERING, AND DEVELOPMENT CENTER',/,T25,'US ARMY MISS00000191
     >ILE COMMAND',/,T18,'REDSTONE ARSENAL, ALABAMA 35898-5252')       00000192
206   FORMAT(/,T20,'X-Y DATA POINTS TO BE FITTED:',//,T12,'NO.',T28,'X',00000193
     >T51,'Y')                                                         00000194
207   FORMAT(T10,I5,1P2D23.13)                                          00000195
208   FORMAT(/,T25,'POLYNOMIAL CONSTRAINTS',//,T8,'NO.',T29,'XC(I)',T37,00000196
     >'NC(I)',T60,'CV(I)')                                             00000197
209   FORMAT(T8,I3,1PD23.13,I7,D23.13)                                  00000198
210   FORMAT(/,T28,'LEAST SQUARES POLYNOMIAL',//,T15,'P(X)=B(0)+B(1)*X+B00000199
     >(2)*X**2+....+B(NP)*X**NP',//,T23,'I',T37,'B(I)',/)              00000200
211   FORMAT(T23,I1,1PD25.13)                                           00000201
212   FORMAT(/,T1,'THE STANDARD DEVIATION FOR THIS POLYNOMIAL OF ORDER '00000202
     >,I1,' IS ',1PD12.5)                                              00000203
213   FORMAT(/,T22,'X-Y EVALUATED DATA POINTS:'//,T12,'NO.',T28,'X',T51,00000204
     >'Y')                                                             00000205
214   FORMAT(/,'INPUT THE EVALUATED DATA VARIABLE LIST FOR OUTPUT BY NAM00000206
     >ELIST WHERE:',//,'"',A1,'"    = X VALUES')                       00000207
215   FORMAT('"',A1,'"    = ',I1,'th DERIVATIVE OF Y AT X')            00000208
216   FORMAT('"',A1,'"    = RADIUS OF CURVATURE AT X',/,'"',A1,'"    = A00000209
     >RC LENGTH',//,'NOTE: VARIABLES WILL BE LISTED IN THE ORDER OF INPU00000210
     >T',//,'CURRENT VALUES ARE:')                                     00000211
217   FORMAT(/,'$PARM AList= "X","0"$',/)                               00000212
218   FORMAT(/,'INPUT THE DATA FILE FORMAT (INCLUDE PARENTHESES)',//,'NO00000213
     >TE: AN EXAMPLE FORMAT IS "(F15.7,E15.6)"',/,T7,'THE DEFAULT FORMAT00000214
     > IS:')                                                           00000215
219   FORMAT(/,'WARNING IN SUBROUTINE FDFOS: NO DATA POINTS HAVE BEEN PR00000216
     >ESCRIBED FOR EVALUATION',/,'OF THE LEAST SQUARES POLYNOMIAL. HENCE00000217
     >, FILE',/)                                                       00000218
220   FORMAT(/,'WILL NOT BE OPENED.')                                   00000219
221   FORMAT(/,'ERROR IN SUBROUTINE FDFOS: OPEN ERROR ON UNIT 4, STATUS 00000220
     >= "UNKNOWN", FILE =',/)                                          00000221
222   FORMAT(/,'ERROR IN SUBROUTINE FDFOS: WRITE ERROR ON UNIT 4, FILE =00000222
     >',/)                                                             00000223
223   FORMAT(/,'ERROR IN SUBROUTINE FDFOS: UNFORMATTED READ ERROR ON UNI00000224
     >T 1')                                                            00000225
224   FORMAT(/,'ERROR IN SUBROUTINE FDFOS: UNFORMATTED READ ERROR ON UNI00000226
     >T 3')                                                            00000227
225   FORMAT('SUBROUTINE NDRUS WAS CALLED FROM SUBROUTINE FDFOS')       00000228
226   FORMAT(/,'ERROR IN SUBROUTINE FDFOS: THE OUTPUT LIST MUST NOT BE E00000229
     >MPTY')                                                           00000230
227   FORMAT(/,'ERROR IN SUBROUTINE FDFOS: ILLEGAL VALUE FOR',/,'AList('00000231
     >,I2,') = ',A1)                                                   00000232
228   FORMAT(/,'ERROR IN SUBROUTINE FDFOS: CLOSE ERROR ON UNIT 4, FILE =00000233
     >',/)                                                             00000234
229   FORMAT('SUBROUTINE CBUS06 WAS CALLED FROM SUBROUTINE FDFOS')      00000235
      END                                                              00000236
```

```
      SUBROUTINE GJEMPS(EPS,INDIC,N,DETER,*)                            00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*    GAUSS-JORDAN ELIMINATION USING MAXIMUM PIVOT STRATEGY (GJEMPS)   *00000006
C*                                                                     *00000007
C*                     REVISION DATE: 21 APRIL 2000                    *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C***********************************************************************00000012
C*                                                                     *00000013
C* SUBROUTINE GJEMPS COMPUTES THE INVERSE OF AN N BY N MATRIX AND/OR   *00000014
C* THE N SOLUTIONS OF A SET OF N LINEAR EQUATIONS IN N UNKNOWNS USING  *00000015
C* GAUSS-JORDAN ELIMINATION WITH MAXIMUM PIVOT STRATEGY.               *00000016
C*                                                                     *00000017
C* INPUT VARIABLES:                                                    *00000018
C*                                                                     *00000019
C* EPS    = MINIMUM ALLOWABLE MAGNITUDE FOR A PIVOT ELEMENT (SUGGESTED *00000020
C*          VALUE 1.0E-10)                                             *00000021
C* INDIC  = CONTROL VARIABLE SUCH THAT:                                *00000022
C*        = NEGATIVE, TO COMPUTE THE INVERSE OF N BY N MATRIX A IN     *00000023
C*          PLACE                                                      *00000024
C*        = ZERO    , TO COMPUTE THE N SOLUTIONS X(1)....X(N)         *00000025
C*          CORRESPONDING TO THE SET OF LINEAR EQUATIONS WITH          *00000026
C*          AUGMENTED MATRIX OF COEFFICIENTS IN THE N BY N+1 ARRAY A   *00000027
C*          AND IN ADDITION COMPUTE THE INVERSE OF THE COEFFICIENT     *00000028
C*          MATRIX IN PLACE                                            *00000029
C*        = POSITIVE, TO COMPUTE THE N SOLUTIONS X(1)....X(N)          *00000030
C*          CORRESPONDING TO THE SET OF LINEAR EQUATIONS WITH          *00000031
C*          AUGMENTED MATRIX OF COEFFICIENTS IN THE N BY N+1 ARRAY A   *00000032
C* N      = NUMBER OF ROWS IN MATRIX A                                 *00000033
C*                                                                     *00000034
C* OUTPUT VARIABLES:                                                   *00000035
C*                                                                     *00000036
C* DETER  = DETERMINATE OF THE ORIGINAL COEFFICIENT MATRIX FORMED BY   *00000037
C*          THE FIRST N COLUMNS OF ARRAY A                             *00000038
C* X      = VECTOR OF N SOLUTIONS                                      *00000039
C*                                                                     *00000040
C* INPUT/OUTPUT VARIABLES:                                             *00000041
C*                                                                     *00000042
C* A      = AUGMENTED COEFFICIENT MATRIX                               *00000043
C*                                                                     *00000044
C* PARAMETERS:                                                         *00000045
C*                                                                     *00000046
C* MXNC   = MAXIMUM NUMBER OF COLUMNS (MXNC = MXNR + 1)                *00000047
C* MXNCM1 = MAXIMUM NUMBER OF COLUMNS MINUS 1 (MXNCM1 = MXNC - 1)      *00000048
C* MXNR   = MAXIMUM NUMBER OF ROWS                                     *00000049
C* MXNRM1 = MAXIMUM NUMBER OF ROWS MINUS 1 (MXNRM1 = MXNR - 1)         *00000050
C*                                                                     *00000051
C* NOTE: SHOULD NO ACCEPTABLE PIVOT ELEMENT BE FOUND, COMPUTATIONS ARE *00000052
C*       TERMINATED AND THE DETERMINATE IS RETURNED WITH A TRUE ZERO   *00000053
C*       VALUE.                                                        *00000054
C*                                                                     *00000055
C* REF: CARNAHAN, B., LUTHER, H.A., AND WILKES, J.O.: APPLIED          *00000056
C*      NUMERICAL METHODS, NEW YORK, 1969, JOHN WILEY & SONS, INC.     *00000057
C*                                                                     *00000058
C***********************************************************************00000059
C                                                                       00000060
```

```
C                                                                       00000061
      IMPLICIT REAL*8(A-H,O-Z)                                          00000062
C                                                                       00000063
      PARAMETER (MXNC=31,MXNCM1=30,MXNR=30,MXNRM1=29)                   00000064
C                                                                       00000065
      DIMENSION A(MXNR,MXNC),IROW(MXNR),JCOL(MXNR),JORD(MXNR),X(MXNR),  00000066
     >Y(MXNR)                                                           00000067
C                                                                       00000068
      COMMON/B/B(0:MXNRM1)                                              00000069
      COMMON/C/C(0:MXNRM1,0:MXNCM1)                                     00000070
C                                                                       00000071
      EQUIVALENCE (A(1,1),C(0,0)),(X(1),B(0))                           00000072
C                                                                       00000073
C                                                                       00000074
C***********************************************************************00000075
C*                                                                     *00000076
C*                     BEGIN ELIMINATION PROCEDURE                     *00000077
C*                                                                     *00000078
C***********************************************************************00000079
C                                                                       00000080
C                                                                       00000081
      IF(N.GT.MXNR) GO TO 114                                           00000082
      MAX=N                                                             00000083
      IF(INDIC.GE.0) MAX=N+1                                            00000084
      DETER=1.0D+00                                                     00000085
      DO 107 K=1,N                                                      00000086
      KM1=K-1                                                           00000087
C                                                                       00000088
C                                                                       00000089
C***********************************************************************00000090
C*                                                                     *00000091
C*                     SEARCH FOR THE PIVOT ELEMENT                    *00000092
C*                                                                     *00000093
C***********************************************************************00000094
C                                                                       00000095
C                                                                       00000096
      PIVOT=0.0D+00                                                     00000097
      DO 103 I=1,N                                                      00000098
      DO 103 J=1,N                                                      00000099
C                                                                       00000100
C                                                                       00000101
C***********************************************************************00000102
C*                                                                     *00000103
C*        SCAN IROW AND JCOL ARRAYS FOR INVALID PIVOT SUBSCRIPTS       *00000104
C*                                                                     *00000105
C***********************************************************************00000106
C                                                                       00000107
C                                                                       00000108
      IF(K.EQ.1) GO TO 102                                              00000109
      DO 101 ISCAN=1,KM1                                                00000110
      DO 101 JSCAN=1,KM1                                                00000111
      IF(I.EQ.IROW(ISCAN)) GO TO 103                                    00000112
101   IF(J.EQ.JCOL(JSCAN)) GO TO 103                                    00000113
102   IF(DABS(A(I,J)).LE.DABS(PIVOT)) GO TO 103                         00000114
      PIVOT=A(I,J)                                                      00000115
      IROW(K)=I                                                         00000116
      JCOL(K)=J                                                         00000117
103   CONTINUE                                                          00000118
C                                                                       00000119
C                                                                       00000120
```

```
C*********************************************************************00000121
C*                                                                    *00000122
C*             INSURE THE SELECTED PIVOT IS LARGER THAN EPS           *00000123
C*                                                                    *00000124
C*********************************************************************00000125
C                                                                      00000126
C                                                                      00000127
      IF(DABS(PIVOT).GT.EPS) GO TO 104                                 00000128
      DETER=0.0D+00                                                    00000129
      RETURN                                                           00000130
C                                                                      00000131
C                                                                      00000132
C*********************************************************************00000133
C*                                                                    *00000134
C*    UPDATE THE DETERMINATE VALUE AND NORMALIZE PIVOT ROW ELEMENTS   *00000135
C*                                                                    *00000136
C*********************************************************************00000137
C                                                                      00000138
C                                                                      00000139
104   DETER=DETER*PIVOT                                                00000140
      DO 105 J=1,MAX                                                   00000141
105   A(IROW(K),J)=A(IROW(K),J)/PIVOT                                  00000142
C                                                                      00000143
C                                                                      00000144
C*********************************************************************00000145
C*                                                                    *00000146
C*              CARRY OUT ELIMINATION AND DEVELOP INVERSE             *00000147
C*                                                                    *00000148
C*********************************************************************00000149
C                                                                      00000150
C                                                                      00000151
      A(IROW(K),JCOL(K))=1.0D+00/PIVOT                                 00000152
      DO 107 I=1,N                                                     00000153
      AIJCK=A(I,JCOL(K))                                               00000154
      IF(I.EQ.IROW(K)) GO TO 107                                       00000155
      A(I,JCOL(K))=-AIJCK/PIVOT                                        00000156
      DO 106 J=1,MAX                                                   00000157
106   IF(J.NE.JCOL(K)) A(I,J)=A(I,J)-AIJCK*A(IROW(K),J)                00000158
107   CONTINUE                                                         00000159
C                                                                      00000160
C                                                                      00000161
C*********************************************************************00000162
C*                                                                    *00000163
C*         ORDER SOLUTION VALUES (IF ANY) AND CREATE JORD ARRAY       *00000164
C*                                                                    *00000165
C*********************************************************************00000166
C                                                                      00000167
C                                                                      00000168
      DO 108 I=1,N                                                     00000169
      JORD(IROW(I))=JCOL(I)                                            00000170
108   IF(INDIC.GE.0) X(JCOL(I))=A(IROW(I),MAX)                         00000171
C                                                                      00000172
C                                                                      00000173
C*********************************************************************00000174
C*                                                                    *00000175
C*                      ADJUST SIGN OF DETERMINANT                    *00000176
C*                                                                    *00000177
C*********************************************************************00000178
C                                                                      00000179
C                                                                      00000180
```

```
      INTCH=0                                                           00000181
      DO 109 I=1,N-1                                                    00000182
      DO 109 J=I+1,N                                                    00000183
      IF(JORD(J).GE.JORD(I)) GO TO 109                                  00000184
      JTEMP=JORD(J)                                                     00000185
      JORD(J)=JORD(I)                                                   00000186
      JORD(I)=JTEMP                                                     00000187
      INTCH=INTCH+1                                                     00000188
109   CONTINUE                                                          00000189
      IF(INTCH/2*2.NE.INTCH) DETER=-DETER                               00000190
C                                                                       00000191
C                                                                       00000192
C***********************************************************************00000193
C*                                                                     *00000194
C*                       UNSCRAMBLE THE INVERSE                        *00000195
C*                                                                     *00000196
C***********************************************************************00000197
C                                                                       00000198
C                                                                       00000199
      IF(INDIC.GT.0) RETURN                                             00000200
      DO 111 J=1,N                                                      00000201
      DO 110 I=1,N                                                      00000202
110   Y(JCOL(I))=A(IROW(I),J)                                           00000203
      DO 111 I=1,N                                                      00000204
111   A(I,J)=Y(I)                                                       00000205
      DO 113 I=1,N                                                      00000206
      DO 112 J=1,N                                                      00000207
112   Y(IROW(J))=A(I,JCOL(J))                                           00000208
      DO 113 J=1,N                                                      00000209
113   A(I,J)=Y(J)                                                       00000210
      RETURN                                                            00000211
C                                                                       00000212
C                                                                       00000213
C***********************************************************************00000214
C*                                                                     *00000215
C*                          ERROR MESSAGES                             *00000216
C*                                                                     *00000217
C***********************************************************************00000218
C                                                                       00000219
C                                                                       00000220
114   WRITE(UNIT=6,FMT=201)N,MXNC                                       00000221
      RETURN 1                                                          00000222
C                                                                       00000223
C                                                                       00000224
C***********************************************************************00000225
C*                                                                     *00000226
C*                         FORMAT STATEMENTS                           *00000227
C*                                                                     *00000228
C***********************************************************************00000229
C                                                                       00000230
C                                                                       00000231
201   FORMAT(/,'ERROR IN SUBROUTINE GJEMPS: THE REQUESTED NUMBER OF ROWS00000232
     >,N',/,'EXCEEDS THE DIMENSIONED MAXIMUM NUMBER OF ROWS, MXNR FOR',/00000233
     >,'N =',I5,' MXNR =',I5,//,'REDIMENSION PARAMETERS:',//,'MXNR   = M00000234
     >AXIMUM NUMBER OF ROWS',/,'MXNC   = MAXIMUM NUMBER OF COLUMNS',/,'M00000235
     >XNRM1 = MAXIMUM NUMBER OF ROWS MINUS 1',/,'MXNCM1 = MAXIMUM NUMBER00000236
     > OF COLUMNS MINUS 1',//,'AND RECOMPILE.')                         00000237
      END                                                               00000238
```

```
      SUBROUTINE LSPRWC(*)                                                  00000001
C                                                                           00000002
C                                                                           00000003
C*************************************************************************00000004
C*                                                                        *00000005
C*    LEAST SQUARES POLYNOMIAL REGRESSION WITH CONSTRAINTS (LSPRWC)       *00000006
C*                                                                        *00000007
C*                      REVISION DATE: 6 JULY 2011                        *00000008
C*                                                                        *00000009
C*************************************************************************00000010
C                                                                           00000011
C*************************************************************************00000012
C*                                                                        *00000013
C*  SUBROUTINE LSPRWC PERFORMS A LEAST SQUARES POLYNOMIAL REGRESSION      *00000014
C*  WITH CONSTRAINTS; THAT IS, A SET OF X-Y DATA POINTS IS CURVE FIT      *00000015
C*  WITH AN NP ORDER POLYNOMIAL OF THE FORM                               *00000016
C*                                                                        *00000017
C*            P(X)=B0+B1*X+B2*X**2+B3*X**3+....+BNP*X**NP                 *00000018
C*                                                                        *00000019
C*  WITH ANY POLYNOMIAL DERIVATIVES, ZERO THROUGH NP, SPECIFIED AT        *00000020
C*  GIVEN X LOCATIONS.  THE PROCEDURE FOLLOWED IS THE METHOD OF LEAST     *00000021
C*  SQUARES USING UNDETERMINED LAGRANGE MULTIPLIERS.                      *00000022
C*                                                                        *00000023
C* INPUT VARIABLES:                                                       *00000024
C*                                                                        *00000025
C* CV     = ARRAY OF POLYNOMIAL DERIVATIVE VALUES                         *00000026
C* NC     = ARRAY OF POLYNOMIAL DERIVATIVE ORDERS (CONSTRAINT ORDER)      *00000027
C* NCONST = NUMBER OF CONSTRAINTS OR (XC,NC,CV) DATA TRIPLES              *00000028
C* NDATA  = NUMBER OF X-Y DATA PAIRS                                      *00000029
C* NP     = POLYNOMIAL ORDER                                              *00000030
C* X      = DATA POINT X VALUE                                            *00000031
C* XC     = ARRAY OF POLYNOMIAL DERIVATIVE LOCATIONS (CONSTRAINT X        *00000032
C*          VALUES)                                                       *00000033
C* Y      = DATA POINT Y VALUE                                            *00000034
C*                                                                        *00000035
C* OUTPUT VARIABLES:                                                      *00000036
C*                                                                        *00000037
C* B      = ARRAY OF REGRESSION COEFFICIENTS                              *00000038
C* SDEV   = STANDARD DEVIATION OF THE X-Y DATA POINTS ABOUT THE           *00000039
C*          REGRESSION LINE                                               *00000040
C*                                                                        *00000041
C* PARAMETERS:                                                            *00000042
C*                                                                        *00000043
C* MXANC  = MAXIMUM NUMBER OF ALLOWABLE CONSTRAINTS                       *00000044
C* MXNC   = MAXIMUM NUMBER OF COLUMNS (MXNC = MXNR + 1)                   *00000045
C* MXNCM1 = MAXIMUM NUMBER OF COLUMNS MINUS 1 (MXNCM1 = MXNC - 1)         *00000046
C* MXNR   = MAXIMUM NUMBER OF ROWS                                        *00000047
C* MXNRM1 = MAXIMUM NUMBER OF ROWS MINUS 1 (MXNRM1 = MXNR - 1)            *00000048
C*                                                                        *00000049
C* REF: CARNAHAN,B., LUTHER, H.A., AND WILKES, J.O.: APPLIED NUMERICAL    *00000050
C*      METHODS, NEW YORK, JOHN WILEY & SONS, 1969, PP. 571-584.          *00000051
C*                                                                        *00000052
C*      WEINSTOCK, R.: CALCULUS OF VARIATIONS WITH APPLICATIONS TO        *00000053
C*      PHYSICS AND ENGINEERING, NEW YORK, DOVER PUBLICATIONS, INC.,      *00000054
C*      1974, P. 6.                                                       *00000055
C*                                                                        *00000056
C*************************************************************************00000057
C                                                                           00000058
C                                                                           00000059
      IMPLICIT REAL*8(A-H,O-Z)                                              00000060
```

```
C                                                                       00000061
      INTEGER COL,COLMAX,FACTRL,ROW,ROWMAX                              00000062
C                                                                       00000063
      PARAMETER (MXANC=20,MXNCM1=30,MXNRM1=29)                          00000064
C                                                                       00000065
      COMMON/B/B(0:MXNRM1)                                              00000066
      COMMON/C/C(0:MXNRM1,0:MXNCM1)                                     00000067
      COMMON/CV/CV(MXANC)                                               00000068
      COMMON/NC/NC(MXANC)                                               00000069
      COMMON/NCONST/NCONST                                              00000070
      COMMON/NDATA/NDATA                                                00000071
      COMMON/NP/NP                                                      00000072
      COMMON/SDEV/SDEV                                                  00000073
      COMMON/XC/XC(MXANC)                                               00000074
C                                                                       00000075
C                                                                       00000076
C*********************************************************************00000077
C*                                                                    *00000078
C*           ZERO THE COEFFICIENT MATRIX AND SOLUTION VECTOR          *00000079
C*                                                                    *00000080
C*********************************************************************00000081
C                                                                       00000082
C                                                                       00000083
      ROWMAX=NP+NCONST                                                  00000084
      COLMAX=ROWMAX+1                                                   00000085
      DO 101 ROW=0,ROWMAX                                               00000086
      DO 101 COL=0,COLMAX                                               00000087
101   C(ROW,COL)=0.0D+00                                                00000088
C                                                                       00000089
C                                                                       00000090
C*********************************************************************00000091
C*                                                                    *00000092
C*                  CALCULATE THE COEFFICIENT MATRIX                  *00000093
C*                                                                    *00000094
C*********************************************************************00000095
C                                                                       00000096
C                                                                       00000097
      REWIND 1                                                          00000098
C                                                                       00000099
C                                                                       00000100
C*********************************************************************00000101
C*                                                                    *00000102
C*          MINIMIZATION EQUATIONS - COEFFICIENTS OF THE B(J)          *00000103
C*                                                                    *00000104
C*********************************************************************00000105
C                                                                       00000106
C                                                                       00000107
102   READ(UNIT=1,END=105,ERR=113)X,Y                                   00000108
      DO 104 JJ=0,NP                                                    00000109
      ROW=JJ                                                            00000110
      DO 103 J=0,NP                                                     00000111
      COL=J                                                             00000112
103   C(ROW,COL)=C(ROW,COL)+POWER(X,J+JJ)                               00000113
C                                                                       00000114
C                                                                       00000115
C*********************************************************************00000116
C*                                                                    *00000117
C*                          VECTOR OF CONSTANTS                       *00000118
C*                                                                    *00000119
C*********************************************************************00000120
```

```
C                                                                       00000121
C                                                                       00000122
104   C(ROW,COLMAX)=C(ROW,COLMAX)+Y*POWER(X,JJ)                         00000123
      GO TO 102                                                         00000124
C                                                                       00000125
C                                                                       00000126
C***********************************************************************00000127
C*                                                                     *00000128
C*                    COEFFICIENTS OF THE LAMBDA(L)                    *00000129
C*                                                                     *00000130
C***********************************************************************00000131
C                                                                       00000132
C                                                                       00000133
105   IF(NCONST.EQ.0) GO TO 108                                         00000134
      DO 106 JJ=0,NP                                                    00000135
      ROW=JJ                                                            00000136
      F1=FACTRL(JJ)                                                     00000137
      DO 106 L=1,NCONST                                                 00000138
      IF(JJ.LT.NC(L)) GO TO 106                                         00000139
      COL=NP+L                                                          00000140
      F2=F1/FACTRL(JJ-NC(L))/2.0D+00                                    00000141
      C(ROW,COL)=F2*POWER(XC(L),JJ-NC(L))                               00000142
106   CONTINUE                                                          00000143
C                                                                       00000144
C                                                                       00000145
C***********************************************************************00000146
C*                                                                     *00000147
C*           CONSTRAINT EQUATIONS - COEFFICIENTS OF THE B(J)           *00000148
C*                                                                     *00000149
C***********************************************************************00000150
C                                                                       00000151
C                                                                       00000152
      DO 107 L=1,NCONST                                                 00000153
      ROW=NP+L                                                          00000154
      C(ROW,COLMAX)=CV(L)                                               00000155
      DO 107 J=NC(L),NP                                                 00000156
      COL=J                                                             00000157
      F1=FACTRL(J)/FACTRL(J-NC(L))                                      00000158
107   C(ROW,COL)=F1*POWER(XC(L),J-NC(L))                                00000159
C                                                                       00000160
C                                                                       00000161
C***********************************************************************00000162
C*                                                                     *00000163
C*                     COMPUTE THE SOLUTION VECTOR                     *00000164
C*                                                                     *00000165
C***********************************************************************00000166
C                                                                       00000167
C                                                                       00000168
108   CALL GJEMPS(1.0D-20,+1,ROWMAX+1,DETER,*112)                       00000169
      IF(DETER.EQ.0.0D+00) GO TO 114                                    00000170
C                                                                       00000171
C                                                                       00000172
C***********************************************************************00000173
C*                                                                     *00000174
C*                   COMPUTE THE STANDARD DEVIATION                    *00000175
C*                                                                     *00000176
C***********************************************************************00000177
C                                                                       00000178
C                                                                       00000179
      SDEV=0.0D+00                                                      00000180
```

```
      IDENOM=NDATA-(NP+1)-NCONST-1                                      00000181
      IF(IDENOM.LE.0) RETURN                                            00000182
      DENOM=IDENOM                                                      00000183
      REWIND 1                                                          00000184
109   READ(UNIT=1,END=111,ERR=113)X,Y                                   00000185
      PX=0.0D+00                                                        00000186
      DO 110 J=NP,1,-1                                                  00000187
110   PX=(PX+B(J))*X                                                    00000188
      PX=PX+B(0)                                                        00000189
      SDEV=SDEV+(Y-PX)**2                                               00000190
      GO TO 109                                                         00000191
111   SDEV=DSQRT(SDEV/DENOM)                                            00000192
      RETURN                                                            00000193
C                                                                       00000194
C                                                                       00000195
C***********************************************************************00000196
C*                                                                     *00000197
C*                          ERROR MESSAGES                             *00000198
C*                                                                     *00000199
C***********************************************************************00000200
C                                                                       00000201
C                                                                       00000202
112   WRITE(UNIT=6,FMT=201)                                             00000203
      RETURN 1                                                          00000204
113   WRITE(UNIT=6,FMT=202)                                             00000205
      RETURN 1                                                          00000206
114   WRITE(UNIT=6,FMT=203)                                             00000207
      RETURN 1                                                          00000208
C                                                                       00000209
C                                                                       00000210
C***********************************************************************00000211
C*                                                                     *00000212
C*                        FORMAT STATEMENTS                            *00000213
C*                                                                     *00000214
C***********************************************************************00000215
C                                                                       00000216
C                                                                       00000217
201   FORMAT('SUBROUTINE GJEMPS WAS CALLED FROM SUBROUTINE LSPRWC')     00000218
202   FORMAT(/,'ERROR IN SUBROUTINE LSPRWC: UNFORMATTED READ ERROR ON UN00000219
     >IT = 1')                                                          00000220
203   FORMAT('SUBROUTINE GJEMPS WAS CALLED FROM SUBROUTINE LSPRWC')     00000221
      END                                                               00000222
```

```
      SUBROUTINE PES(*)                                                 00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*                POLYNOMIAL EVALUATION SUBROUTINE (PES)               *00000006
C*                                                                     *00000007
C*                      REVISION DATE: 3 MAY 2002                      *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C***********************************************************************00000012
C*                                                                     *00000013
C* GIVEN X AND THE COEFFICIENTS B(0),B(1),....,B(NP), SUBROUTINE PES   *00000014
C* EVALUATES THE K-TH DERIVATIVE OF POLYNOMIALS OF THE FORM:           *00000015
C*                                                                     *00000016
C*             P(X)=B(0)+B(1)*X+B(2)*X**2+....+B(NP)*X**NP             *00000017
C*                                                                     *00000018
C* INPUT VARIABLES:                                                    *00000019
C*                                                                     *00000020
C* B      = ARRAY OF POLYNOMIAL COEFFICIENTS                           *00000021
C* NP     = POLYNOMIAL ORDER                                           *00000022
C* X      = X VALUE FOR EVALUATION OF THE POLYNOMIAL                   *00000023
C*                                                                     *00000024
C* OUTPUT VARIABLES:                                                   *00000025
C*                                                                     *00000026
C* R      = VALUE AT X OF THE RADIUS OF CURVATURE OF THE POLYNOMIAL    *00000027
C* S      = VALUE AT X OF THE APPROXIMATE ARC LENGTH ALONG THE         *00000028
C*          POLYNOMIAL                                                 *00000029
C* YK     = VALUE AT X OF THE K-TH DERIVATIVE OF THE POLYNOMIAL        *00000030
C*                                                                     *00000031
C* PARAMETERS:                                                         *00000032
C*                                                                     *00000033
C* MXNR   = MAXIMUM NUMBER OF ROWS                                     *00000034
C* MXNRM1 = MAXIMUM NUMBER OF ROWS MINUS 1 (MXNRM1 = MXNR - 1)         *00000035
C*                                                                     *00000036
C***********************************************************************00000037
C                                                                       00000038
C                                                                       00000039
      IMPLICIT REAL*8(A-H,O-Z)                                          00000040
C                                                                       00000041
      INTEGER FACTRL                                                    00000042
C                                                                       00000043
      PARAMETER (MXNRM1=29)                                             00000044
C                                                                       00000045
      COMMON/B/B(0:MXNRM1)                                              00000046
      COMMON/NP/NP                                                      00000047
C                                                                       00000048
      DIMENSION YK(0:9)                                                 00000049
C                                                                       00000050
C                                                                       00000051
      REWIND 2                                                          00000052
      REWIND 3                                                          00000053
      S=0.0E+00                                                         00000054
      N=0                                                               00000055
101   READ(UNIT=2,END=106,ERR=107)X                                     00000056
      N=N+1                                                             00000057
C                                                                       00000058
C                                                                       00000059
C***********************************************************************00000060
```

```
C*                                                                     *00000061
C*      EVALUATE THE NK-TH DERIVATIVE OF THE POLYNOMIAL (0 TO NP)      *00000062
C*                                                                     *00000063
C***********************************************************************00000064
C                                                                       00000065
C                                                                       00000066
      DO 103 NK=0,NP                                                    00000067
      YK(NK)=0.0D+00                                                    00000068
      DO 102 J=NP,NK+1,-1                                               00000069
102   YK(NK)=(YK(NK)+FACTRL(J)*B(J)/FACTRL(J-NK))*X                     00000070
103   YK(NK)=YK(NK)+FACTRL(NK)*B(NK)                                    00000071
C                                                                       00000072
C                                                                       00000073
C***********************************************************************00000074
C*                                                                     *00000075
C*         EVALUATE THE RADIUS OF CURVATURE OF THE POLYNOMIAL          *00000076
C*                                                                     *00000077
C***********************************************************************00000078
C                                                                       00000079
C                                                                       00000080
      R=1.0E+32                                                         00000081
      IF(NP.LT.2) GO TO 104                                             00000082
      IF(YK(2).EQ.0.0E+00) GO TO 104                                    00000083
      R=((1.0E+00+YK(1)*YK(1))**1.5)/DABS(YK(2))                        00000084
104   CONTINUE                                                          00000085
C                                                                       00000086
C                                                                       00000087
C***********************************************************************00000088
C*                                                                     *00000089
C*                      CALCULATE THE ARC LENGTH                       *00000090
C*                                                                     *00000091
C***********************************************************************00000092
C                                                                       00000093
C                                                                       00000094
C                                                                       00000095
      IF(N.EQ.1) GO TO 105                                              00000096
      DeltaX=X-Xsave                                                    00000097
      DeltaY=YK(0)-Ysave                                                00000098
      DeltaS=DSQRT(DeltaX*DeltaX+DeltaY*DeltaY)                         00000099
      S=S+DeltaS                                                        00000100
105   Xsave=X                                                           00000101
      Ysave=YK(0)                                                       00000102
      WRITE(UNIT=3,ERR=108)X,(YK(K),K=0,NP),R,S                         00000103
      GO TO 101                                                         00000104
C                                                                       00000105
C                                                                       00000106
106   END FILE 3                                                        00000107
      RETURN                                                            00000108
C                                                                       00000109
C                                                                       00000110
C***********************************************************************00000111
C*                                                                     *00000112
C*                           ERROR MESSAGES                            *00000113
C*                                                                     *00000114
C***********************************************************************00000115
C                                                                       00000116
C                                                                       00000117
107   WRITE(UNIT=6,FMT=201)                                             00000118
      RETURN 1                                                          00000119
108   WRITE(UNIT=6,FMT=202)                                             00000120
```

```
      RETURN 1                                                          00000121
C                                                                       00000122
C                                                                       00000123
C***********************************************************************00000124
C*                                                                     *00000125
C*                          FORMAT STATEMENTS                          *00000126
C*                                                                     *00000127
C***********************************************************************00000128
C                                                                       00000129
C                                                                       00000130
201    FORMAT(/,'ERROR IN SUBROUTINE PES: UNFORMATTED READ ERROR ON UNIT 00000131
     >= 2')                                                             00000132
202    FORMAT(/,'ERROR IN SUBROUTINE PES: UNFORMATTED WRITE ERROR ON UNIT00000133
     > = 3')                                                            00000134
       END                                                              00000135
```

```
      SUBROUTINE PODS(*)                                                00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*            POLYNOMIAL ORDER DEFINITION SUBROUTINE (PODS)             *00000006
C*                                                                     *00000007
C*                  REVISION DATE: 11 SEPTEMBER 2007                   *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C***********************************************************************00000012
C*                                                                     *00000013
C*  SUBROUTINE PODS DEFINES THE POLYNOMIAL ORDER FOR PROGRAM LSPRWC.    *00000014
C*                                                                     *00000015
C* INPUT VARIABLES:                                                    *00000016
C*                                                                     *00000017
C* NDATA  = NUMBER OF X,Y DATA POINTS TO BE FIT                        *00000018
C* NCONST = NUMBER OF CONSTRAINTS                                      *00000019
C*                                                                     *00000020
C* INPUT/OUTPUT VARIABLES:                                             *00000021
C*                                                                     *00000022
C* NP     = POLYNOMIAL ORDER                                           *00000023
C*                                                                     *00000024
C***********************************************************************00000025
C                                                                       00000026
C***********************************************************************00000027
C*                                                                     *00000028
C* PARAMETERS:                                                         *00000029
C*                                                                     *00000030
C* MXNAC  = MAXIMUM NUMBER OF ALLOWABLE CONSTRAINTS                    *00000031
C*                                                                     *00000032
C***********************************************************************00000033
C                                                                       00000034
C                                                                       00000035
      IMPLICIT REAL*8(A-H,O-Z)                                          00000036
C                                                                       00000037
      PARAMETER (MXNAC=20,MXNR=30,MXNRM1=29)                            00000038
C                                                                       00000039
      COMMON/NC/NC(MXNAC)                                               00000040
      COMMON/NCONST/NCONST                                              00000041
      COMMON/NDATA/NDATA                                                00000042
      COMMON/NP/NP                                                      00000043
C                                                                       00000044
      DATA NP/3/                                                        00000045
C                                                                       00000046
      NAMELIST/PARM/NP                                                  00000047
C                                                                       00000048
C                                                                       00000049
C***********************************************************************00000050
C*                                                                     *00000051
C*                     INPUT THE POLYNOMIAL ORDER                      *00000052
C*                                                                     *00000053
C***********************************************************************00000054
C                                                                       00000055
C                                                                       00000056
      NPMAX=MIN0(9,NDATA-NCONST-1)                                      00000057
101   WRITE(UNIT=6,FMT=201)NPMAX                                        00000058
      CALL NDWUS('PARM',6,*103)                                         00000059
      CALL NDWUSI('NP',1,1,1,NP,*103)                                   00000060
```

```
      CALL NDWUSE(*103)                                                 00000061
      CALL NDRUS('PARM',4,*101,*104)                                    00000062
      READ(UNIT=4,NML=PARM,ERR=101)                                     00000063
      CALL NDRUSE(*101,*104)                                            00000064
      IF(NP.LT.0.OR.NP.GT.9) GO TO 105                                  00000065
      IF(NP.GT.NPMAX) GO TO 106                                         00000066
      DO 102 I=1,NCONST                                                 00000067
      IF(NC(I).LT.0.OR.NC(I).GT.NP) GO TO 107                           00000068
102   CONTINUE                                                          00000069
      RETURN                                                            00000070
C                                                                       00000071
C                                                                       00000072
C*********************************************************************00000073
C*                                                                    *00000074
C*                          ERROR MESSAGES                            *00000075
C*                                                                    *00000076
C*********************************************************************00000077
C                                                                       00000078
C                                                                       00000079
103   WRITE(UNIT=6,FMT=204)                                             00000080
      GO TO 108                                                         00000081
104   WRITE(UNIT=6,FMT=205)                                             00000082
      GO TO 108                                                         00000083
105   WRITE(UNIT=6,FMT=206)NP                                           00000084
      GO TO 108                                                         00000085
106   WRITE(UNIT=6,FMT=207)NP,NCONST,NDATA,NPMAX                        00000086
      GO TO 108                                                         00000087
107   WRITE(UNIT=6,FMT=208)NC(I),I,NP                                   00000088
108   WRITE(UNIT=6,FMT=202)                                             00000089
      READ(UNIT=5,FMT=203)CCV                                           00000090
      RETURN 1                                                          00000091
C                                                                       00000092
C                                                                       00000093
C*********************************************************************00000094
C*                                                                    *00000095
C*                       FORMAT STATEMENTS                            *00000096
C*                                                                    *00000097
C*********************************************************************00000098
C                                                                       00000099
C                                                                       00000100
201   FORMAT(/,'INPUT THE POLYNOMIAL ORDER BY NAMELIST WHERE:',//,'NP   00000101
     > = THE POLYNOMIAL ORDER',//,'NOTE: NP MUST BE IN THE RANGE OF 0 TO00000102
     > 9.',/,T7,'THERE MUST BE AT LEAST NP+NCONST+1 X-Y DATA POINTS.',/,00000103
     >T7,'THE MAXIMUM VALUE FOR NP IS ',I5,'.',//,'CURRENT VALUES ARE:')00000104
202   FORMAT(/,T19,'- ENTER/RETURN TO CONTINUE -')                      00000105
203   FORMAT(A1)                                                        00000106
204   FORMAT('SUBROUTINE NDWUS WAS CALLED FROM SUBROUTINE PODS')        00000107
205   FORMAT('SUBROUTINE NDRUS WAS CALLED FROM SUBROUTINE PODS')        00000108
206   FORMAT(/,'ERROR IN SUBROUTINE PODS: NP = ',I5,' IS NOT ALLOWED.',/00000109
     >,'THE POLYNOMIAL ORDER MUST BE GREATER THAN OR EQUAL TO 0 AND LESS00000110
     > THAN OR EQUAL',/,'TO 9.')                                       00000111
207   FORMAT(/,'ERROR IN SUBROUTINE PODS: NP = ',I5,' IS NOT ALLOWED FOR00000112
     > NCONST = ',I5,' AND',/,'NDATA = ',I5,'.  THERE MUST BE AT LEAST N00000113
     >P+2*NCONST X-Y DATA POINTS.  THE',/,'MAXIMUM VALUE FOR NP IS ',I5,00000114
     >'.')                                                             00000115
208   FORMAT(/,'ERROR IN SUBROUTINE PODS: NC(',I3,') = ',I5,' IS NOT ALL00000116
     >OWED FOR NP = ',I5,'.',/,'THE CONSTRAINT ORDER MUST BE GREATER THA00000117
     >N OR EQUAL TO 0 AND LESS THAN OR EQUAL TO NP.')                  00000118
      END                                                               00000119
```

```
      FUNCTION POWER(X,N)                                               00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*     INTEGER POWERS OF REAL NUMBERS FUNCTION SUBPROGRAM (POWER)      *00000006
C*                                                                     *00000007
C*                     REVISION DATE: 15 JUNE 1989                     *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C                                                                       00000012
      REAL*8 POWER,X                                                    00000013
      POWER=1.0D+00                                                     00000014
      IF(N.EQ.0) RETURN                                                 00000015
      DO 101 I=1,N                                                      00000016
101   POWER=POWER*X                                                     00000017
      END                                                               00000018
```

```
      SUBROUTINE QPS(*)                                                 00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*                     QUICK PLOT SUBROUTINE (QPS)                     *00000006
C*                                                                     *00000007
C*                     REVISION DATE: 1 JULY 2011                      *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C***********************************************************************00000012
C*                                                                     *00000013
C*    SUBROUTINE QPS WRITES DATA FILES TO CONSTRUCT A QUICK PLOT OF    *00000014
C*    RESULTS  FOR  PROGRAM  LSPRWC USING THE  PostScript CARTESIAN    *00000015
C*    COORDINATE PLOT PROGRAM PSCCPP.                                  *00000016
C*                                                                     *00000017
C* INPUT VARIABLES:                                                    *00000018
C*                                                                     *00000019
C* NCONST = NUMBER OF CONSTRAINTS                                      *00000020
C* X      = X VALUE FOR EVALUATION OF THE POLYNOMIAL                   *00000021
C* XC     = ARRAY OF CONSTRAINT X VALUES                               *00000022
C* Y      = Y VALUE FROM EVALUATION OF THE POLYNOMIAL AT X             *00000023
C*                                                                     *00000024
C* PARAMETERS:                                                         *00000025
C*                                                                     *00000026
C* MXNAC  = MAXIMUM NUMBER OF ALLOWABLE CONSTRAINTS                    *00000027
C*                                                                     *00000028
C***********************************************************************00000029
C                                                                       00000030
C                                                                       00000031
      IMPLICIT REAL*8(A-H,O-Z)                                          00000032
C                                                                       00000033
      CHARACTER*10 File                                                 00000034
C                                                                       00000035
      PARAMETER (MXNAC=20,One=1.0E+00,Zero=0.0E+00)                     00000036
C                                                                       00000037
      COMMON/NCONST/NCONST                                              00000038
      COMMON/XC/XC(MXNAC)                                               00000039
C                                                                       00000040
      DIMENSION File(3)                                                 00000041
C                                                                       00000042
      DATA File/'@lsprwc.cl','@lsprwc.ed','@lsprwc.dp'/,Norm/0/         00000043
C                                                                       00000044
      NAMELIST/PARM/Norm,Xmax,Xmin,Ymax,Ymin                            00000045
C                                                                       00000046
      FNX(Q)=(Q-Xmin)/(Xmax-Xmin)                                       00000047
      FNY(Q)=(Q-Ymin)/(Ymax-Ymin)                                       00000048
C                                                                       00000049
C                                                                       00000050
C***********************************************************************00000051
C*                                                                     *00000052
C*                     FIND THE RANGE OF THE DATA                      *00000053
C*                                                                     *00000054
C***********************************************************************00000055
C                                                                       00000056
C                                                                       00000057
      Xmin=+1.0D+75                                                     00000058
      Xmax=-1.0D+75                                                     00000059
      Ymin=+1.0D+75                                                     00000060
```

```
      Ymax=-1.0D+75                                                     00000061
      REWIND 1                                                          00000062
101   READ(UNIT=1,END=102,ERR=116)X,Y                                   00000063
      Xmin=DMIN1(X,Xmin)                                                00000064
      Xmax=DMAX1(X,Xmax)                                                00000065
      Ymin=DMIN1(Y,Ymin)                                                00000066
      Ymax=DMAX1(Y,Ymax)                                                00000067
      GO TO 101                                                         00000068
102   REWIND 3                                                          00000069
103   READ(UNIT=3,END=104,ERR=117)X,Y                                   00000070
      Xmin=DMIN1(X,Xmin)                                                00000071
      Xmax=DMAX1(X,Xmax)                                                00000072
      Ymin=DMIN1(Y,Ymin)                                                00000073
      Ymax=DMAX1(Y,Ymax)                                                00000074
      GO TO 103                                                         00000075
104   IF(NCONST.EQ.0) GO TO 106                                         00000076
      DO 105 I=1,NCONST                                                 00000077
      Xmin=DMIN1(XC(I),Xmin)                                            00000078
105   Xmax=DMAX1(XC(I),Xmax)                                            00000079
106   IF(Xmin.GE.Xmax) RETURN                                           00000080
      IF(Ymin.GE.Ymax) RETURN                                           00000081
107   WRITE(UNIT=6,FMT=201)                                             00000082
      CALL NDWUS('PARM',6,*118)                                         00000083
      CALL NDWUSI('Norm',1,1,1,Norm,*118)                               00000084
      CALL NDWUSD('Xmax',1,1,1,Xmax,*118)                               00000085
      CALL NDWUSD('Xmin',1,1,1,Xmin,*118)                               00000086
      CALL NDWUSD('Ymax',1,1,1,Ymax,*118)                               00000087
      CALL NDWUSD('Ymin',1,1,1,Ymin,*118)                               00000088
      CALL NDWUSE(*118)                                                 00000089
      CALL NDRUS('PARM',4,*107,*119)                                    00000090
      READ(UNIT=4,NML=PARM,ERR=107)                                     00000091
      CALL NDRUSE(*107,*119)                                            00000092
C                                                                       00000093
C                                                                       00000094
C*********************************************************************00000095
C*                                                                   *00000096
C*                    MARK THE CONSTRAINT LOCATIONS                  *00000097
C*                                                                   *00000098
C*********************************************************************00000099
C                                                                       00000100
C                                                                       00000101
      N=1                                                               00000102
      OPEN(UNIT=4,FILE=File(N),STATUS='UNKNOWN',FORM='FORMATTED',       00000103
     >ERR=120)                                                          00000104
      IF(NCONST.EQ.0) GO TO 109                                         00000105
      DO 108 I=1,NCONST                                                 00000106
      IF(Norm.EQ.0) WRITE(UNIT=4,FMT=202,ERR=121)XC(I),Ymin,INT(Zero)   00000107
      IF(Norm.EQ.1) WRITE(UNIT=4,FMT=202,ERR=121)FNX(XC(I)),Zero,       00000108
     >INT(Zero)                                                         00000109
      IF(Norm.EQ.0) WRITE(UNIT=4,FMT=202,ERR=121)XC(I),Ymax,INT(One)    00000110
      IF(Norm.EQ.1) WRITE(UNIT=4,FMT=202,ERR=121)FNX(XC(I)),One,        00000111
     >INT(One)                                                          00000112
108   CONTINUE                                                          00000113
      GO TO 110                                                         00000114
109   WRITE(UNIT=4,FMT=202,ERR=121)Zero,Zero,INT(Zero)                  00000115
110   CLOSE(UNIT=4,STATUS='KEEP',ERR=122)                               00000116
C                                                                       00000117
C                                                                       00000118
C*********************************************************************00000119
C*                                                                   *00000120
```

```
C*                      WRITE THE EVALUATED DATA                        *00000121
C*                                                                      *00000122
C***********************************************************************00000123
C                                                                        00000124
C                                                                        00000125
      N=2                                                                00000126
      OPEN(UNIT=4,FILE=File(N),STATUS='UNKNOWN',FORM='FORMATTED',        00000127
     >ERR=120)                                                           00000128
111   REWIND 3                                                           00000129
112   READ(UNIT=3,END=113,ERR=117)X,Y                                    00000130
      IF(Norm.EQ.0) WRITE(UNIT=4,FMT=202,ERR=121)X,Y                     00000131
      IF(Norm.EQ.1) WRITE(UNIT=4,FMT=202,ERR=121)FNX(X),FNY(Y)           00000132
      GO TO 112                                                          00000133
113   CLOSE(UNIT=4,STATUS='KEEP',ERR=122)                                00000134
C                                                                        00000135
C                                                                        00000136
C***********************************************************************00000137
C*                                                                      *00000138
C*                MARK THE X-Y DATA POINTS TO BE FITTED                 *00000139
C*                                                                      *00000140
C***********************************************************************00000141
C                                                                        00000142
C                                                                        00000143
      N=3                                                                00000144
      OPEN(UNIT=4,FILE=File(N),STATUS='UNKNOWN',FORM='FORMATTED',        00000145
     >ERR=120)                                                           00000146
      REWIND 1                                                           00000147
114   READ(UNIT=1,END=115,ERR=116)X,Y                                    00000148
      IF(Norm.EQ.0) WRITE(UNIT=4,FMT=202,ERR=121)X,Y                     00000149
      IF(Norm.EQ.1) WRITE(UNIT=4,FMT=202,ERR=121)FNX(X),FNY(Y)           00000150
      GO TO 114                                                          00000151
115   CLOSE(UNIT=4,STATUS='KEEP',ERR=122)                                00000152
C                                                                        00000153
C                                                                        00000154
C***********************************************************************00000155
C*                                                                      *00000156
C*                         CONTSTRUCT THE PLOT                          *00000157
C*                                                                      *00000158
C***********************************************************************00000159
C                                                                        00000160
C                                                                        00000161
      RETURN                                                             00000162
C                                                                        00000163
C                                                                        00000164
C***********************************************************************00000165
C*                                                                      *00000166
C*                            ERROR MESSAGES                            *00000167
C*                                                                      *00000168
C***********************************************************************00000169
C                                                                        00000170
C                                                                        00000171
116   WRITE(UNIT=6,FMT=205)                                              00000172
      RETURN 1                                                           00000173
117   WRITE(UNIT=6,FMT=206)                                              00000174
      RETURN 1                                                           00000175
118   WRITE(UNIT=6,FMT=207)                                              00000176
      RETURN 1                                                           00000177
119   WRITE(UNIT=6,FMT=208)                                              00000178
      RETURN 1                                                           00000179
120   WRITE(UNIT=6,FMT=209)File(N)                                       00000180
```

```
      RETURN 1                                                          00000181
121   WRITE(UNIT=6,FMT=210)File(N)                                      00000182
      RETURN 1                                                          00000183
122   WRITE(UNIT=6,FMT=211)File(N)                                      00000184
      RETURN 1                                                          00000185
C                                                                       00000186
C                                                                       00000187
C***********************************************************************00000188
C*                                                                     *00000189
C*                        FORMAT STATEMENTS                            *00000190
C*                                                                     *00000191
C***********************************************************************00000192
C                                                                       00000193
C                                                                       00000194
201    FORMAT(/,'INPUT THE PLOT VARIABLES BY NAMELIST WHERE:',//,'Norm   00000195
     >= RENormILIZATION CONTROL',/,T8,'= 0, TO NOT NormALIZE THE PLOT DA00000196
     >TA',/,T8,'= 1, TO NormALIZE THE PLOT DATA',/,'Xmax   = MAXIMUM X-V00000197
     >ALUE',/,'Xmin   = MINIMUM X-VALUE',/,'Ymax   = MAXIMUM Y-VALUE',/,00000198
     >'Ymin   = MINIMUM Y-VALUE',//,'CURRENT VALUES ARE:')              00000199
202    FORMAT(2E15.6,I15)                                               00000200
203    FORMAT('lsprwc.l')                                               00000201
204    FORMAT('lsprwc.ps')                                              00000202
205    FORMAT(/,'ERROR IN SUBROUTINE QPS: UNFORMATTED READ ERROR ON UNIT100000203
     >')                                                                00000204
206    FORMAT(/,'ERROR IN SUBROUTINE QPS: UNFORMATTED READ ERROR ON UNIT300000205
     >')                                                                00000206
207    FORMAT('SUBROUTINE NDWUS WAS CALLED FROM SUBROUTINE QPS')        00000207
208    FORMAT('SUBROUTINE NDRUS WAS CALLED FROM SUBROUTINE QPS')        00000208
209    FORMAT(/,'ERROR IN SUBROUTINE QPS: OPEN ERROR ON UNIT 4, STATUS = 00000209
     >"UNKNOWN", FILE =',A10)                                           00000210
210    FORMAT(/,'ERROR IN SUBROUTINE QPS: WRITE ERROR ON UNIT 4, FILE = '00000211
     >,A10)                                                             00000212
211    FORMAT(/,'ERROR IN SUBROUTINE QPS: CLOSE ERROR ON UNIT 4, FILE =',00000213
     >A10)                                                              00000214
      END                                                               00000215
```

```
      SUBROUTINE XDPEDS(LCV2,*,*)                                       00000001
C                                                                       00000002
C                                                                       00000003
C*********************************************************************00000004
C*                                                                     *00000005
C*     X DATA POINTS FOR EVALUATION DEFINITION SUBROUTINE (XDPEDS)     *00000006
C*                                                                     *00000007
C*                      REVISION DATE: 1 JULY 2011                     *00000008
C*                                                                     *00000009
C*********************************************************************00000010
C                                                                       00000011
C*********************************************************************00000012
C*                                                                     *00000013
C*  SUBROUTINE XDPEDS DEFINES THE X COORDINATE SET FOR EVALUATION OF   *00000014
C*  THE RESULTANT LEAST SQUARES POLYNOMIAL SET.                        *00000015
C*                                                                     *00000016
C* INPUT/OUTPUT VARIABLES:                                             *00000017
C*                                                                     *00000018
C* X      = ARRAY OF X COORDINATES FOR EVALUATION OF THE LEAST SQUARES *00000019
C*          POLYNOMIAL SET                                             *00000020
C*                                                                     *00000021
C* OUTPUT VARIABLES:                                                   *00000022
C*                                                                     *00000023
C* NEVAL  = NUMBER OF X COORDINATES FOR EVALUATION                     *00000024
C*                                                                     *00000025
C* PARAMETERS:                                                         *00000026
C*                                                                     *00000027
C* MNXCE  = MAXIMUM NUMBER OF X COORDINATES FOR POLYNOMIAL EVALUATION  *00000028
C*                                                                     *00000029
C*********************************************************************00000030
C                                                                       00000031
C                                                                       00000032
      IMPLICIT REAL*8(A-H,O-Z)                                          00000033
C                                                                       00000034
      CHARACTER CCV*1,DFmt*3,File*80,Fmt*80                             00000035
C                                                                       00000036
      PARAMETER (R_NaN=-999.E+00)                                       00000037
      PARAMETER (MNXCE=101)                                             00000038
C                                                                       00000039
      COMMON/NEVAL/NEVAL                                                00000040
      COMMON/XINT/XINT                                                  00000041
      COMMON/XMAX/XMAX                                                  00000042
      COMMON/XMIN/XMIN                                                  00000043
C                                                                       00000044
      DIMENSION X(MNXCE)                                                00000045
C                                                                       00000046
      DATA DFmt/'(*)'/,NEVAL/0/                                         00000047
C                                                                       00000048
      NAMELIST/PARM/X,XINT,XMAX,XMIN                                    00000049
C                                                                       00000050
C                                                                       00000051
C*********************************************************************00000052
C*                                                                     *00000053
C*                INPUT THE X DATA POINTS FOR EVALUATION               *00000054
C*                   OF THE LEAST SQUARES POLYNOMIAL                   *00000055
C*                                                                     *00000056
C*********************************************************************00000057
C                                                                       00000058
C                                                                       00000059
      IF(NEVAL.EQ.0) WRITE(UNIT=6,FMT=201)                              00000060
```

```
      IF(NEVAL.NE.0) WRITE(UNIT=6,FMT=202)                              00000061
      READ(UNIT=5,FMT=203)LCV1                                          00000062
      REWIND 2                                                          00000063
      LCV2=1                                                            00000064
      GO TO (101,107,112,116),LCV1                                      00000065
C                                                                       00000066
C                                                                       00000067
C*********************************************************************00000068
C*                                                                    *00000069
C*                          NAMELIST INPUT                            *00000070
C*                                                                    *00000071
C*********************************************************************00000072
C                                                                       00000073
C                                                                       00000074
101   DO 102 I=1,MNXCE                                                  00000075
102   X(I)=R_NaN                                                        00000076
103   WRITE(UNIT=6,FMT=204)MNXCE                                        00000077
      WRITE(UNIT=6,FMT=205)                                             00000078
      CALL NDRUS('PARM',4,*103,*117)                                    00000079
      READ(UNIT=4,NML=PARM,ERR=103)                                     00000080
      CALL NDRUSE(*103,*117)                                            00000081
      DO 104 NEVAL=MNXCE,1,-1                                           00000082
      IF(X(NEVAL).NE.R_NaN) GO TO 105                                   00000083
104   CONTINUE                                                          00000084
105   DO 106 I=1,NEVAL                                                  00000085
106   WRITE(UNIT=2,ERR=122)X(I)                                         00000086
      GO TO 115                                                         00000087
C                                                                       00000088
C                                                                       00000089
C*********************************************************************00000090
C*                                                                    *00000091
C*                    FORMATTED DISK FILE INPUT                       *00000092
C*                                                                    *00000093
C*********************************************************************00000094
C                                                                       00000095
C                                                                       00000096
107   WRITE(UNIT=6,FMT=206)                                             00000097
      WRITE(UNIT=6,FMT=207)                                             00000098
      READ(UNIT=5,FMT=208)File                                          00000099
108   WRITE(UNIT=6,FMT=209)                                             00000100
      WRITE(UNIT=6,FMT=210)                                             00000101
      CALL DFCUS(FMT,DFmt,*108)                                         00000102
      OPEN(UNIT=4,FILE=File,STATUS='OLD',ERR=118)                       00000103
      REWIND 4                                                          00000104
      NEVAL=0                                                           00000105
      IF(Fmt(1:3).EQ.DFmt) GO TO 110                                    00000106
109   READ(UNIT=4,FMT=Fmt,END=111,ERR=119)X(1)                          00000107
      WRITE(UNIT=2,ERR=122)X(1)                                         00000108
      NEVAL=NEVAL+1                                                     00000109
      GO TO 109                                                         00000110
110   READ(UNIT=4,FMT=*,END=111,ERR=119)X(1)                            00000111
      WRITE(UNIT=2,ERR=122)X(1)                                         00000112
      NEVAL=NEVAL+1                                                     00000113
      GO TO 110                                                         00000114
111   CLOSE(UNIT=4,STATUS='KEEP',ERR=120)                               00000115
      GO TO 115                                                         00000116
C                                                                       00000117
C                                                                       00000118
C*********************************************************************00000119
C*                                                                    *00000120
```

```
C*                MINIMUM, MAXIMUM, AND INTERVAL VALUES                 *00000121
C*                                                                      *00000122
C***********************************************************************00000123
C                                                                        00000124
C                                                                        00000125
112   WRITE(UNIT=6,FMT=211)                                              00000126
      CALL NDWUS('PARM',6,*121)                                          00000127
      CALL NDWUSD('XINT',1,1,1,XINT,*121)                                00000128
      CALL NDWUSD('XMAX',1,1,1,XMAX,*121)                                00000129
      CALL NDWUSD('XMIN',1,1,1,XMIN,*121)                                00000130
      CALL NDWUSE(*121)                                                  00000131
      CALL NDRUS('PARM',4,*112,*117)                                     00000132
      READ(UNIT=4,NML=PARM,ERR=112)                                      00000133
      CALL NDRUSE(*112,*117)                                             00000134
      NEVAL=0                                                            00000135
      X(1)=XMIN                                                          00000136
      DUM1=XMAX+XINT/2                                                   00000137
113   IF(X(1).GT.DUM1) GO TO 114                                         00000138
      WRITE(UNIT=2,ERR=122)X(1)                                          00000139
      NEVAL=NEVAL+1                                                      00000140
      DUM3=X(1)                                                          00000141
      X(1)=XMIN+NEVAL*XINT                                               00000142
      GO TO 113                                                          00000143
114   IF(DUM3.EQ.XMAX) GO TO 115                                         00000144
      WRITE(UNIT=2,ERR=122)XMAX                                          00000145
      NEVAL=NEVAL+1                                                      00000146
115   END FILE 2                                                         00000147
116   RETURN                                                             00000148
C                                                                        00000149
C                                                                        00000150
C***********************************************************************00000151
C*                                                                     *00000152
C*                          ERROR MESSAGES                             *00000153
C*                                                                     *00000154
C***********************************************************************00000155
C                                                                        00000156
C                                                                        00000157
117   WRITE(UNIT=6,FMT=212)                                              00000158
      GO TO 124                                                          00000159
118   WRITE(UNIT=6,FMT=213)                                              00000160
      CALL CBUS06(6,File,*123)                                           00000161
      RETURN 1                                                           00000162
119   WRITE(UNIT=6,FMT=214)                                              00000163
      CALL CBUS06(6,File,*123)                                           00000164
      RETURN 1                                                           00000165
120   WRITE(UNIT=6,FMT=215)                                              00000166
      CALL CBUS06(6,File,*123)                                           00000167
      RETURN 1                                                           00000168
121   WRITE(UNIT=6,FMT=216)                                              00000169
      GO TO 124                                                          00000170
122   WRITE(UNIT=6,FMT=217)                                              00000171
      RETURN 1                                                           00000172
123   WRITE(UNIT=6,FMT=218)                                              00000173
      RETURN 1                                                           00000174
124   WRITE(UNIT=6,FMT=219)                                              00000175
      READ(UNIT=5,FMT=220)CCV                                            00000176
      RETURN 2                                                           00000177
C                                                                        00000178
C                                                                        00000179
C***********************************************************************00000180
```

```
C*                                                                     *00000181
C*                          FORMAT STATEMENTS                          *00000182
C*                                                                     *00000183
C***********************************************************************00000184
C                                                                       00000185
C                                                                       00000186
201   FORMAT(/,'SELECT THE SOURCE OF INPUT FOR THE X DATA TO BE EVALUATE00000187
     >D FROM THE FOLLOWING',/,'LIST:',//,'1, FOR KEYBOARD INPUT VIA NAME00000188
     >LIST',/,'2, FOR FORMATTED DISK FILE INPUT',/,'3, FOR INPUT OF MINI00000189
     >MUM, MAXIMUM, AND INTERVAL VALUES')                               00000190
202   FORMAT(/,'SELECT THE SOURCE OF INPUT FOR THE X DATA TO BE EVALUATE00000191
     >D FROM THE FOLLOWING',/,'LIST:',//,'1, FOR KEYBOARD INPUT VIA NAME00000192
     >LIST',/,'2, FOR FORMATTED DISK FILE INPUT',/,'3, FOR INPUT OF MINI00000193
     >MUM, MAXIMUM, AND INTERVAL VALUES',/,'4, TO USE THE PREVIOUSLY PRE00000194
     >SCRIBED X VALUES')                                               00000195
203   FORMAT(I1)                                                        00000196
204   FORMAT(/,'INPUT THE DATA SET X VALUES (',I3,' MAX) BY NAMELIST WHE00000197
     >RE:',//,'X      = ARRAY OF X VALUES',//,'CURRENT VALUES ARE:')    00000198
205   FORMAT(/,'$PARM X=____,____,____$',/)                             00000199
206   FORMAT(/,'DATA SETS ARE INPUT FROM FORMATTED DISK FILES AS X VALUE00000200
     >S WHERE:',//,'X      = X VALUE')                                 00000201
207   FORMAT(/,'INPUT THE FILE NAME OF THE FORMATTED DISK FILE DATA SET.00000202
     >')                                                               00000203
208   FORMAT(A80)                                                       00000204
209   FORMAT(/,'INPUT THE DATA FILE FORMAT (INCLUDE PARENTHESES)')      00000205
210   FORMAT('NOTE: AN EXAMPLE FORMAT IS "(E15.6)"',/,T7,'ENTER "(*)" FO00000206
     >R A FREE FIELD READ (DEFAULT FORMAT)')                           00000207
211   FORMAT(/,'INPUT THE X DATA MAXIMUM, MINIMUM, AND INTERVAL VALUES B00000208
     >Y NAMELIST WHERE:',//,'XINT   = X DATA POINT INTERVAL',/,'XMAX   =00000209
     > MAXIMUM X DATA VALUE',/,'XMIN   = MINIMUM X DATA VALUE',//,'CURRE00000210
     >NT VALUES ARE:')                                                 00000211
212   FORMAT('SUBROUTINE NDRUS WAS CALLED FROM PROGRAM LSPRWC')         00000212
213   FORMAT(/,'ERROR IN PROGRAM LSPRWC: OPEN ERROR ON UNIT 4, STATUS = 00000213
     >"OLD", FILE =',/)                                                00000214
214   FORMAT(/,'ERROR IN PROGRAM LSPRWC: READ ERROR ON UNIT 4, FILE =',/00000215
     >)                                                                00000216
215   FORMAT(/,'ERROR IN PROGRAM LSPRWC: CLOSE ERROR ON UNIT 4, FILE =',00000217
     >/)                                                               00000218
216   FORMAT('SUBROUTINE NDWUS WAS CALLED FROM PROGRAM LSPRWC')         00000219
217   FORMAT(/,'ERROR IN PROGRAM LSPRWC: UNFORMATTED WRITE ERROR ON UNIT00000220
     > 2')                                                             00000221
218   FORMAT('SUBROUTINE CBUS06 WAS CALLED FROM PROGRAM LSPRWC')        00000222
219   FORMAT(/,T19,'- ENTER/RETURN TO CONTINUE -')                      00000223
220   FORMAT(A1)                                                        00000224
      END                                                               00000225
```

```
      SUBROUTINE XYDIS(*,*)                                              00000001
C                                                                        00000002
C                                                                        00000003
C*************************************************************************00000004
C*                                                                       *00000005
C*                  X-Y DATA INPUT SUBROUTINE (XYDIS)                    *00000006
C*                                                                       *00000007
C*                     REVISION DATE: 1 JULY 2011                        *00000008
C*                                                                       *00000009
C*************************************************************************00000010
C                                                                        00000011
C*************************************************************************00000012
C*                                                                       *00000013
C* SUBROUTINE XYDIS DEFINES THE X,Y DATA POINTS TO BE FIT FOR PROGRAM     *00000014
C* LSPRWC.                                                               *00000015
C*                                                                       *00000016
C* INPUT/OUTPUT VARIABLES:                                               *00000017
C*                                                                       *00000018
C* X      = ARRAY OF X COORDINATES                                       *00000019
C* Y      = ARRAY OF Y COORDINATES                                       *00000020
C*                                                                       *00000021
C* OUTPUT VARIABLES:                                                     *00000022
C*                                                                       *00000023
C* NDATA  = NUMBER OF X,Y DATA POINTS TO BE FIT                          *00000024
C*                                                                       *00000025
C* PARAMETERS:                                                           *00000026
C*                                                                       *00000027
C* MNXYDP = MAXIMUM NUMBER OF (X,Y) DATA PAIRS FOR NAMELIST INPUT        *00000028
C*                                                                       *00000029
C*************************************************************************00000030
C                                                                        00000031
C                                                                        00000032
      IMPLICIT REAL*8(A-H,O-Z)                                           00000033
C                                                                        00000034
      CHARACTER CCV*1,Crdimg*80,DFmt*3,File*80,Fmt*80,Fmt_s*80           00000035
C                                                                        00000036
      PARAMETER (R_NaN=-999.E+00)                                        00000037
      PARAMETER (MNXYDP=101)                                             00000038
C                                                                        00000039
      COMMON/NDATA/NDATA                                                 00000040
      COMMON/XINT/XINT                                                   00000041
      COMMON/XMAX/XMAX                                                   00000042
      COMMON/XMIN/XMIN                                                   00000043
C                                                                        00000044
      DIMENSION X(MNXYDP),Y(MNXYDP)                                      00000045
C                                                                        00000046
      DATA DFmt/'(*)'/                                                   00000047
C                                                                        00000048
      NAMELIST/PARM/X,Y                                                  00000049
C                                                                        00000050
C                                                                        00000051
C*************************************************************************00000052
C*                                                                       *00000053
C*                INPUT THE X-Y DATA POINTS TO BE FITTED                 *00000054
C*                                                                       *00000055
C*************************************************************************00000056
C                                                                        00000057
C                                                                        00000058
      WRITE(UNIT=6,FMT=203)                                              00000059
      READ(UNIT=5,FMT=204)LCV1                                           00000060
```

```
      REWIND 1                                                          00000061
      IF(LCV1.EQ.2) GO TO 106                                           00000062
C                                                                       00000063
C                                                                       00000064
C*********************************************************************00000065
C*                                                                    *00000066
C*                          NAMELIST INPUT                            *00000067
C*                                                                    *00000068
C*********************************************************************00000069
C                                                                       00000070
C                                                                       00000071
      DO 101 I=1,MNXYDP                                                 00000072
      X(I)=R_NaN                                                        00000073
101   Y(I)=0.0                                                          00000074
102   WRITE(UNIT=6,FMT=205)MNXYDP                                       00000075
      WRITE(UNIT=6,FMT=206)                                             00000076
      CALL NDRUS('PARM',4,*102,*119)                                    00000077
      READ(UNIT=4,NML=PARM,ERR=102)                                     00000078
      CALL NDRUSE(*102,*119)                                            00000079
      DO 103 NDATA=MNXYDP,1,-1                                          00000080
      IF(X(NDATA).NE.R_NaN) GO TO 104                                   00000081
103   CONTINUE                                                          00000082
104   DO 105 I=1,NDATA                                                  00000083
105   WRITE(UNIT=1,ERR=120)X(I),Y(I)                                    00000084
      GO TO 112                                                         00000085
C                                                                       00000086
C                                                                       00000087
C*********************************************************************00000088
C*                                                                    *00000089
C*                     FORMATTED DISK FILE INPUT                      *00000090
C*                                                                    *00000091
C*********************************************************************00000092
C                                                                       00000093
C                                                                       00000094
106   WRITE(UNIT=6,FMT=207)                                             00000095
      WRITE(UNIT=6,FMT=208)                                             00000096
      READ(UNIT=5,FMT=209)File                                          00000097
107   WRITE(UNIT=6,FMT=210)                                             00000098
      WRITE(UNIT=6,FMT=211)                                             00000099
      CALL DFCUS(Fmt,DFmt,*107)                                         00000100
C                                                                       00000101
      OPEN(UNIT=4,FILE=File,STATUS='OLD',ERR=121)                       00000102
      REWIND 4                                                          00000103
      NDATA=0                                                           00000104
C                                                                       00000105
108   READ(UNIT=4,FMT=209,END=122,ERR=123)Crdimg                        00000106
      CALL CBUS01(Crdimg,L)                                             00000107
      IF(L.EQ.0) GO TO 108                                              00000108
      IF(Fmt(1:3).NE.DFmt) READ(Crdimg,FMT=Fmt,ERR=108)X(1),Y(1)        00000109
      IF(Fmt(1:3).EQ.DFmt) READ(Crdimg,*,ERR=108)X(1),Y(1)              00000110
      BACKSPACE 4                                                       00000111
C                                                                       00000112
      IF(Fmt(1:3).EQ.DFmt) GO TO 110                                    00000113
109   READ(UNIT=4,FMT=Fmt,END=111,ERR=123)X(1),Y(1)                     00000114
      WRITE(UNIT=1,ERR=120)X(1),Y(1)                                    00000115
      NDATA=NDATA+1                                                     00000116
      GO TO 109                                                         00000117
110   READ(UNIT=4,FMT=*,END=111,ERR=123)X(1),Y(1)                       00000118
      WRITE(UNIT=1,ERR=120)X(1),Y(1)                                    00000119
      NDATA=NDATA+1                                                     00000120
```

```
      GO TO 110                                                          00000121
111   CLOSE(UNIT=4,STATUS='KEEP',ERR=125)                                00000122
112   END FILE 1                                                         00000123
C                                                                        00000124
C                                                                        00000125
C************************************************************************00000126
C*                                                                      *00000127
C*   SEARCH FOR THE MINIMUM AND MAXIMUM X VALUES WITHIN THE DATA SET    *00000128
C*                                                                      *00000129
C************************************************************************00000130
C                                                                        00000131
C                                                                        00000132
      REWIND 1                                                           00000133
      XMAX=-1.0D+75                                                      00000134
      XMIN=+1.0D+75                                                      00000135
      XSAV=-1.0D+75                                                      00000136
113   READ(UNIT=1,END=114,ERR=124)X(1),Y(1)                              00000137
      IF(X(1).LT.XSAV) GO TO 126                                         00000138
      XMAX=DMAX1(XMAX,X(1))                                              00000139
      XMIN=DMIN1(XMIN,X(1))                                              00000140
      XSAV=X(1)                                                          00000141
      GO TO 113                                                          00000142
114   IF(XMAX.EQ.XMIN) GO TO 127                                         00000143
      XINT=(XMAX-XMIN)/1.0D+02                                           00000144
C                                                                        00000145
C                                                                        00000146
C************************************************************************00000147
C*                                                                      *00000148
C*                     DISPLAY THE X-Y DATA SET                         *00000149
C*                                                                      *00000150
C************************************************************************00000151
C                                                                        00000152
C                                                                        00000153
115   WRITE(UNIT=6,FMT=212)                                              00000154
      CALL YNOUS(*116,*118,*115)                                         00000155
116   REWIND 1                                                           00000156
      WRITE(UNIT=6,FMT=213)                                              00000157
      DO 117 I=1,NDATA                                                   00000158
      READ(UNIT=1,ERR=124)X(1),Y(1)                                      00000159
      IF(MOD(I,20).NE.0) GO TO 117                                       00000160
      WRITE(UNIT=6,FMT=201)                                              00000161
      READ(UNIT=5,FMT=202)CCV                                            00000162
      WRITE(UNIT=6,FMT=213)                                              00000163
117   WRITE(UNIT=6,FMT=214)I,X(1),Y(1)                                   00000164
      WRITE(UNIT=6,FMT=201)                                              00000165
      READ(UNIT=5,FMT=202)CCV                                            00000166
118   RETURN                                                             00000167
C                                                                        00000168
C                                                                        00000169
C************************************************************************00000170
C*                                                                      *00000171
C*                           ERROR MESSAGES                             *00000172
C*                                                                      *00000173
C************************************************************************00000174
C                                                                        00000175
C                                                                        00000176
119   WRITE(UNIT=6,FMT=215)                                              00000177
      GO TO 129                                                          00000178
120   WRITE(UNIT=6,FMT=216)                                              00000179
      RETURN 1                                                           00000180
```

```
121   WRITE(UNIT=6,FMT=217)                                                  00000181
      CALL CBUS06(6,File,*128)                                               00000182
      RETURN 1                                                               00000183
122   WRITE(UNIT=6,FMT=218)                                                  00000184
      CALL CBUS06(6,File,*128)                                               00000185
      RETURN 1                                                               00000186
123   WRITE(UNIT=6,FMT=219)                                                  00000187
      CALL CBUS06(6,File,*128)                                               00000188
      RETURN 1                                                               00000189
124   WRITE(UNIT=6,FMT=220)                                                  00000190
      RETURN 1                                                               00000191
125   WRITE(UNIT=6,FMT=221)                                                  00000192
      CALL CBUS06(6,File,*128)                                               00000193
      RETURN 1                                                               00000194
126   WRITE(UNIT=6,FMT=222)                                                  00000195
      GO TO 129                                                              00000196
127   WRITE(UNIT=6,FMT=223)                                                  00000197
      GO TO 129                                                              00000198
128   WRITE(UNIT=6,FMT=224)                                                  00000199
      RETURN 1                                                               00000200
129   WRITE(UNIT=6,FMT=201)                                                  00000201
      READ(UNIT=5,FMT=202)CCV                                                00000202
      RETURN 2                                                               00000203
C                                                                            00000204
C                                                                            00000205
C*****************************************************************************00000206
C*                                                                           *00000207
C*                          FORMAT STATEMENTS                                *00000208
C*                                                                           *00000209
C*****************************************************************************00000210
C                                                                            00000211
C                                                                            00000212
201   FORMAT(/,T19,'- ENTER/RETURN TO CONTINUE -')                           00000213
202   FORMAT(A1)                                                             00000214
203   FORMAT(/,'SELECT THE SOURCE OF INPUT FOR THE X-Y DATA TO BE FITTED00000215
     > FROM',/,'THE FOLLOWING LIST:',//,'1, FOR KEYBOARD INPUT VIA NAMEL00000216
     >IST',/,'2, FOR FORMATTED DISK FILE INPUT',//,'NOTE: THE X-Y DATA M00000217
     >UST BE MONATONICALLY INCREASING IN X.')                               00000218
204   FORMAT(I1)                                                             00000219
205   FORMAT(/,'INPUT THE DATA SET (X,Y) PAIRS (',I3,' MAX) BY NAMELIST 00000220
     >WHERE:',//,'X      = ARRAY OF X VALUES',/,'Y      = ARRAY OF Y VAL00000221
     >UES',//,'CURRENT VALUES ARE:')                                        00000222
206   FORMAT(/,'$PARM X=____,____,____,Y=____,____,____$',/)                 00000223
207   FORMAT(/,'DATA SETS ARE INPUT FROM FORMATTED DISK FILES AS (X,Y) P00000224
     >AIRS WHERE:',//,'X      = X VALUE',/,'Y      = Y VALUE')              00000225
208   FORMAT(/,'INPUT THE FILE NAME OF THE FORMATTED DISK FILE DATA SET.00000226
     >')                                                                    00000227
209   FORMAT(A80)                                                            00000228
210   FORMAT(/,'INPUT THE DATA FILE FORMAT (INCLUDE PARENTHESES)')           00000229
211   FORMAT('NOTE: AN EXAMPLE FORMAT IS "(2E15.6)"',/,T7,'ENTER"(*)" FO00000230
     >R A FREE FIELD READ (DEFAULT FORMAT)')                                00000231
212   FORMAT(/,'SHOULD THE X-Y DATA BE DISPLAYED FOR VERIFICATION? (Y/N)00000232
     >')                                                                    00000233
213   FORMAT(/,T10,'NO.',T26,'X',T49,'Y')                                    00000234
214   FORMAT(T8,I5,1P2D23.13)                                                00000235
215   FORMAT('SUBROUTINE NDRUS WAS CALLED FROM SUBROUTINE XYDIS')            00000236
216   FORMAT(/,'ERROR IN SUBROUTINE XYDIS: UNFORMATTED WRITE ERROR ON UN00000237
     >IT 1')                                                                00000238
217   FORMAT(/,'ERROR IN SUBROUTINE XYDIS: OPEN ERROR ON UNIT 4, STATUS 00000239
     >= "OLD", FILE =',/)                                                   00000240
```

```
218   FORMAT(/,'ERROR IN SUBROUTINE XYDIS:  UNANTICPATED EOF ON UNIT 4, 00000241
     >FILE =',/)                                                        00000242
219   FORMAT(/,'ERROR IN SUBROUTINE XYDIS: READ ERROR ON UNIT 4, FILE ='00000243
     >,/)                                                               00000244
220   FORMAT(/,'ERROR IN SUBROUTINE XYDIS: UNFORMATTED READ ERROR ON UNI00000245
     >T 1')                                                             00000246
221   FORMAT(/,'ERROR IN PROGRAM LSPRWC: CLOSE ERROR ON UNIT 4, FILE =',00000247
     >/)                                                                00000248
222   FORMAT(/,'ERROR IN SUBROUTINE XYDIS: ALL X-Y DATA POINTS MUST BE',00000249
     >/,'MONOTONICALLY INCREASING IN X.')                               00000250
223   FORMAT(/,'ERROR IN SUBROUTINE XYDIS: ALL X-Y DATA POINTS HAVE THE 00000251
     >SAME X VALUE LEADING TO',/,'A SINGULAR MATRIX.')                  00000252
224   FORMAT('SUBROUTINE CBUS06 WAS CALLED FROM SUBROUTINE XYDIS')      00000253
      END                                                               00000254
```

APPENDIX C
FORTRAN TOOL LIBRARY

```
      SUBROUTINE CBUS01(Buf,L)                                          00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*            CHARACTER BUFFER UTILITY SUBROUTINE (CBUS01)             *00000006
C*                                                                     *00000007
C*                   REVISION DATE: 3 FEBRUARY 1997                    *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C***********************************************************************00000012
C*                                                                     *00000013
C* SUBROUTINE CBUS01 FINDS THE NON-TRAILING-BLANK LENGTH OF CHARACTER  *00000014
C* BUFFERS.                                                            *00000015
C*                                                                     *00000016
C* INPUT/OUTPUT VARIABLES:                                             *00000017
C*                                                                     *00000018
C* Buf    = CHARACTER BUFFER                                           *00000019
C*                                                                     *00000020
C* OUTPUT VARIABLES:                                                   *00000021
C*                                                                     *00000022
C* L      = NON-TRAILING-BLANK LENGTH OF Buf                           *00000023
C*                                                                     *00000024
C***********************************************************************00000025
C                                                                       00000026
C                                                                       00000027
      CHARACTER Blank*1,Buf*(*)                                         00000028
C                                                                       00000029
      SAVE Blank                                                        00000030
C                                                                       00000031
      DATA Blank/' '/                                                   00000032
C                                                                       00000033
      DO 101 L=LEN(Buf),1,-1                                            00000034
      IF(Buf(L:L).NE.Blank) RETURN                                      00000035
101   CONTINUE                                                          00000036
      L=0                                                               00000037
      END                                                               00000038
```

```
      SUBROUTINE CBUS06(LUnit,Buf,*)                                    00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*            CHARACTER BUFFER UTILITY SUBROUTINE (CBUS06)             *00000006
C*                                                                     *00000007
C*                     REVISION DATE: 11 MARCH 1999                    *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C***********************************************************************00000012
C*                                                                     *00000013
C*    SUBROUTINE CBUS06 WRITES CHARACTER BUFFERS, LESS THE TRAILING    *00000014
C*    BLANKS, TO UNIT LUnit USING DYNAMIC FORMAT CONSTRUCTION.         *00000015
C*                                                                     *00000016
C* INPUT/OUTPUT VARIABLES:                                             *00000017
C*                                                                     *00000018
C* LUnit  = LOGICAL UNIT NUMBER                                        *00000019
C* Buf    = CHARACTER BUFFER                                           *00000020
C*                                                                     *00000021
C***********************************************************************00000022
C                                                                       00000023
C                                                                       00000024
      CHARACTER Buf*(*),Fmt*15                                          00000025
C                                                                       00000026
      INTEGER LUnit                                                     00000027
C                                                                       00000028
      CALL CBUS01(Buf,L)                                                00000029
      IF(L.EQ.0) L=1                                                    00000030
      WRITE(Fmt,FMT=201,ERR=101)L                                       00000031
      WRITE(UNIT=LUnit,FMT=Fmt,ERR=102)(Buf(1:L))                       00000032
      RETURN                                                            00000033
C                                                                       00000034
C                                                                       00000035
C***********************************************************************00000036
C*                                                                     *00000037
C*                          ERROR MESSAGES                             *00000038
C*                                                                     *00000039
C***********************************************************************00000040
C                                                                       00000041
C                                                                       00000042
101   WRITE(UNIT=6,FMT=202)                                             00000043
      RETURN 1                                                          00000044
102   WRITE(UNIT=6,FMT=203)LUnit                                        00000045
      RETURN 1                                                          00000046
C                                                                       00000047
C                                                                       00000048
C***********************************************************************00000049
C*                                                                     *00000050
C*                         FORMAT STATEMENTS                           *00000051
C*                                                                     *00000052
C***********************************************************************00000053
C                                                                       00000054
C                                                                       00000055
201   FORMAT(2H(A,I5,1H))                                               00000056
202   FORMAT(/,'ERROR IN SUBROUTINE CBUS06: WRITE ERROR',/,'WHILE ATTEMP00000057
     >TING TO WRITE VARIABLE L TO Fmt')                                 00000058
203   FORMAT(/,'ERROR IN SUBROUTINE CBUS06: WRITE ERROR',/,'WHILE ATTEMP00000059
     >TING TO WRITE VARIABLE Buf TO UNIT = ',I2)                        00000060
```

```
END                                                              00000061
```

```
      SUBROUTINE DFCUS(Fmt,DFmt,*)                                      00000001
C                                                                       00000002
C                                                                       00000003
C*********************************************************************00000004
C*                                                                     *00000005
C*       DYNAMIC FORMAT CONSTRUCTION UTILITY SUBROUTINE (DFCUS)        *00000006
C*                                                                     *00000007
C*                    REVISION DATE: 20 NOVEMBER 2000                  *00000008
C*                                                                     *00000009
C*********************************************************************00000010
C                                                                       00000011
C*********************************************************************00000012
C*                                                                     *00000013
C*   SUBROUTINE DFCUS READS A FORTRAN FORMAT FROM UNIT 5, STORES THE   *00000014
C*   FORMAT IN A CHARACTER BUFFER, AND CHECKS THE FORMAT FOR ERRORS.   *00000015
C*   Blank FORMATS ARE REPLACED WITH A DEFAULT FORMAT.                 *00000016
C*                                                                     *00000017
C* INPUT VARIABLES:                                                    *00000018
C*                                                                     *00000019
C* DFmt   = DEFAULT FORMAT CHARACTER BUFFER                            *00000020
C*                                                                     *00000021
C* OUTPUT VARIABLES:                                                   *00000022
C*                                                                     *00000023
C* Fmt    = FORMAT CHARACTER BUFFER                                    *00000024
C*                                                                     *00000025
C*********************************************************************00000026
C                                                                       00000027
C                                                                       00000028
      CHARACTER CCV*1,DFmt*(*),Fmt*(*),LParn*1,RParn*1                  00000029
C                                                                       00000030
      SAVE LParn,RParn                                                  00000031
C                                                                       00000032
      DATA LParn/'('/,RParn/')'/                                        00000033
C                                                                       00000034
      READ(UNIT=5,FMT=201)Fmt                                           00000035
      ENTRY DFCUSE(Fmt,DFmt,*)                                          00000036
      CALL CBUS03(Fmt)                                                  00000037
      CALL CBUS01(Fmt,LFmt)                                             00000038
      IF(LFmt.GT.0) GO TO 101                                           00000039
      CALL CBUS01(DFmt,LDFmt)                                           00000040
      LFmt=LEN(Fmt)                                                     00000041
      IF(LDFmt.GT.LFmt) GO TO 102                                       00000042
      Fmt(1:LDFmt)=DFmt(1:LDFmt)                                        00000043
      RETURN                                                            00000044
101   IF(Fmt(1:1).EQ.LParn.AND.Fmt(LFmt:LFmt).EQ.RParn) RETURN          00000045
C                                                                       00000046
C                                                                       00000047
C*********************************************************************00000048
C*                                                                     *00000049
C*                          ERROR MESSAGES                             *00000050
C*                                                                     *00000051
C*********************************************************************00000052
C                                                                       00000053
C                                                                       00000054
      WRITE(UNIT=6,FMT=202)                                             00000055
      CALL CBUS06(6,Fmt,*103)                                           00000056
      WRITE(UNIT=6,FMT=203)                                             00000057
      READ(UNIT=5,FMT=201)CCV                                           00000058
      RETURN 1                                                          00000059
102   WRITE(UNIT=6,FMT=204)LDFmt,LFmt                                   00000060
```

```
      STOP                                                              00000061
103   WRITE(UNIT=6,FMT=205)                                             00000062
      RETURN 1                                                          00000063
C                                                                       00000064
C                                                                       00000065
C*********************************************************************00000066
C*                                                                    *00000067
C*                         FORMAT STATEMENTS                          *00000068
C*                                                                    *00000069
C*********************************************************************00000070
C                                                                       00000071
C                                                                       00000072
201   FORMAT(A80)                                                       00000073
202   FORMAT(/,'ERROR IN SUBROUTINE DFCUS: ILLEGAL VALUE FOR Fmt =')    00000074
203   FORMAT('FORMATS MUST BEGIN WITH "(" AND END WITH ")"',//,T20,'- EN00000075
     >TER/RETURN TO CONTINUE -')                                        00000076
204   FORMAT(/,'FATAL ERROR IN SUBROUTINE DFCUS:',//,'THE NON-TRAILING-B00000077
     >LANK LENGTH OF THE DEFAULT FORMAT CHARACTER',/,'BUFFER, LDFmt =',I00000078
     >3,' IS GREATER THAN THE LENGTH OF THE FORMAT',/,'CHARACTER BUFFER,00000079
     > LFmt =',I3,//,'EDIT AND RECOMPILE THE FORTRAN CODE.')            00000080
205   FORMAT('SUBROUTINE CBUS06 WAS CALLED FROM SUBROUTINE DFCUS')      00000081
      END                                                               00000082
```

```
      SUBROUTINE NDRUS(NBuf,KUnit,*,*)                                  00000001
C                                                                       00000002
C                                                                       00000003
C*********************************************************************00000004
C*                                                                     *00000005
C*          NAMELIST-DIRECTED READ UTILITY SUBROUTINE (NDRUS)          *00000006
C*                                                                     *00000007
C*                     REVISION DATE: 23 MARCH 1999                    *00000008
C*                                                                     *00000009
C*********************************************************************00000010
C                                                                       00000011
C*********************************************************************00000012
C*                                                                     *00000013
C*  SUBROUTINE NDRUS EXECUTES AN INTELLIGENT  NAMELIST-DIRECTED READ   *00000014
C*  PROCESS FOR  PROGRAM PSCCPP WITH INPUT VIA THE TEMPORARY SCRATCH   *00000015
C*  FILE ON LOGICAL UNIT NUMBER Unit.                                  *00000016
C*                                                                     *00000017
C* PARAMETERS:                                                         *00000018
C*                                                                     *00000019
C* IBS    = INPUT CHARACTER BUFFER SIZE                                *00000020
C*                                                                     *00000021
C* VARIABLES:                                                          *00000022
C*                                                                     *00000023
C* NBuf   = NAMELIST GROUP-NAME CHARACTER BUFFER                       *00000024
C* IBuf   = INPUT CHARACTER BUFFER                                     *00000025
C* LUnit  = INPUT TEMPORARY SCRATCH FILE LOGICAL UNIT NUMBER           *00000026
C*                                                                     *00000027
C*********************************************************************00000028
C                                                                       00000029
C                                                                       00000030
      CHARACTER AEnd*4,Amsand*1,Blank*1,Comma*1,DEnd*4,Dollar*1,IBuf*80,00000031
     >NBuf*(*),RBuf*80,Switch*1                                         00000032
C                                                                       00000033
      INTEGER EPontr,SPontr,TPontr                                      00000034
C                                                                       00000035
      LOGICAL OP                                                        00000036
C                                                                       00000037
      PARAMETER (IBS=80)                                                00000038
C                                                                       00000039
      EQUIVALENCE (Amsand,AEnd(1:1)),(Dollar,DEnd(1:1))                 00000040
C                                                                       00000041
      SAVE AEnd,Blank,Comma,DEnd,EPontr,LUnit,SPontr,Switch,TPontr      00000042
C                                                                       00000043
      DATA AEnd/'&END'/,Blank/' '/,Comma/','/,DEnd/'$END'/,Switch/'U'/  00000044
C                                                                       00000045
C                                                                       00000046
C*********************************************************************00000047
C*                                                                     *00000048
C*       CHECK FOR A VALID NAMELIST GROUP-NAME CHARACTER BUFFER        *00000049
C*                                                                     *00000050
C*********************************************************************00000051
C                                                                       00000052
C                                                                       00000053
      LUnit=KUnit                                                       00000054
      CALL CBUS04(NBuf,Switch,*110)                                     00000055
      CALL CBUS03(NBuf)                                                 00000056
      CALL CBUS01(NBuf,L)                                               00000057
      IF(L.EQ.0) GO TO 111                                              00000058
      IF(L+2.GT.IBS) GO TO 112                                          00000059
C                                                                       00000060
```

```
C                                                                       00000061
C***********************************************************************00000062
C*                                                                     *00000063
C*    OPEN THE TEMPORARY SCRATCH FILE ON LOGICAL UNIT NUMBER LUnit     *00000064
C*                                                                     *00000065
C***********************************************************************00000066
C                                                                       00000067
C                                                                       00000068
      INQUIRE(UNIT=LUnit,ERR=113,OPENED=OP)                             00000069
      IF(OP.EQV..TRUE.) CLOSE(UNIT=LUnit,STATUS='DELETE',ERR=114)       00000070
      OPEN(UNIT=LUnit,STATUS='SCRATCH',FORM='FORMATTED',ERR=115)        00000071
C                                                                       00000072
C                                                                       00000073
C***********************************************************************00000074
C*                                                                     *00000075
C*     SUPPLY THE NAMELIST INITIALIZATION AND NAMELIST GROUP-NAME      *00000076
C*                                                                     *00000077
C***********************************************************************00000078
C                                                                       00000079
C                                                                       00000080
      CALL CBUS07(RBuf)                                                 00000081
      RBuf(2:2)=Dollar                                                  00000082
      RBuf(3:L+3)=NBuf(1:L)                                             00000083
      WRITE(UNIT=LUnit,FMT=201,ERR=116)RBuf                             00000084
C                                                                       00000085
C                                                                       00000086
C***********************************************************************00000087
C*                                                                     *00000088
C*                   READ THE NAMELIST INPUT BUFFER                    *00000089
C*                                                                     *00000090
C***********************************************************************00000091
C                                                                       00000092
C                                                                       00000093
101   READ(UNIT=5,FMT=201,ERR=101)IBuf                                  00000094
C                                                                       00000095
C                                                                       00000096
C***********************************************************************00000097
C*                                                                     *00000098
C*                   CHECK FOR A BLANK INPUT BUFFER                    *00000099
C*                                                                     *00000100
C***********************************************************************00000101
C                                                                       00000102
C                                                                       00000103
      CALL CBUS01(IBuf,J)                                               00000104
      IF(J.NE.0) GO TO 102                                              00000105
C                                                                       00000106
C                                                                       00000107
C***********************************************************************00000108
C*                                                                     *00000109
C*                    SUPPLY THE DEFAULT CONDITION                     *00000110
C*                                                                     *00000111
C***********************************************************************00000112
C                                                                       00000113
C                                                                       00000114
      CALL CBUS07(IBuf)                                                 00000115
      IBuf(2:2)=Dollar                                                  00000116
      WRITE(UNIT=LUnit,FMT=201,ERR=116)IBuf                             00000117
      GO TO 109                                                         00000118
C                                                                       00000119
C                                                                       00000120
```

```
C*********************************************************************00000121
C*                                                                    *00000122
C*       SEARCH FOR THE NAMELIST GROUP-NAME IN THE INPUT BUFFER       *00000123
C*                                                                    *00000124
C*********************************************************************00000125
C                                                                      00000126
C                                                                      00000127
102   SPontr=1                                                         00000128
      CALL CBUS04(IBuf,Switch,*110)                                    00000129
      CALL CBUS01(IBuf,EPontr)                                         00000130
      TPontr=INDEX(IBuf(SPontr:EPontr),NBuf(1:L))                      00000131
      IF(TPontr.EQ.0) GO TO 108                                        00000132
C                                                                      00000133
C                                                                      00000134
C*********************************************************************00000135
C*                                                                    *00000136
C*                  CHECK FOR A VALID NAMELIST INPUT                  *00000137
C*                                                                    *00000138
C*********************************************************************00000139
C                                                                      00000140
C                                                                      00000141
      SPontr=TPontr-1                                                  00000142
      IF(SPontr.LT.1) GO TO 104                                        00000143
      DO 103 I=1,SPontr                                                00000144
      IF(IBuf(I:I).EQ.Blank) GO TO 103                                 00000145
      IF(IBuf(I:I).EQ.Dollar) GO TO 103                                00000146
      IF(IBuf(I:I).EQ.Amsand) GO TO 103                                00000147
      RETURN 1                                                         00000148
103   CONTINUE                                                         00000149
C                                                                      00000150
104   SPontr=TPontr+L                                                  00000151
      IF(SPontr.GT.EPontr) GO TO 105                                   00000152
      IF(IBuf(SPontr:SPontr).EQ.Blank) GO TO 105                       00000153
      IF(IBuf(SPontr:SPontr).EQ.Comma) GO TO 105                       00000154
      IF(IBuf(SPontr:SPontr).EQ.Dollar) GO TO 105                      00000155
      IF(IBuf(SPontr:SPontr).EQ.Amsand) GO TO 105                      00000156
      RETURN 1                                                         00000157
C                                                                      00000158
105   SPontr=SPontr-1                                                  00000159
      DO 106 I=1,SPontr                                                00000160
106   IBuf(I:I)=Blank                                                  00000161
      GO TO 108                                                        00000162
C                                                                      00000163
C                                                                      00000164
C*********************************************************************00000165
C*                                                                    *00000166
C*            CONTINUE TO READ AND FLUSH THE INPUT BUFFER             *00000167
C*                                                                    *00000168
C*********************************************************************00000169
C                                                                      00000170
C                                                                      00000171
107   READ(UNIT=5,FMT=201,ERR=107)IBuf                                 00000172
      CALL CBUS04(IBuf,Switch,*110)                                    00000173
      CALL CBUS01(IBuf,EPontr)                                         00000174
108   WRITE(UNIT=LUnit,FMT=201,ERR=116)IBuf                            00000175
C                                                                      00000176
C                                                                      00000177
C*********************************************************************00000178
C*                                                                    *00000179
C*             CHECK FOR TERMINATION IN THE INPUT BUFFER              *00000180
```

```
C*                                                                     *00000181
C***********************************************************************00000182
C                                                                       00000183
C                                                                       00000184
      SPontr=EPontr-3                                                   00000185
      IF(IBuf(EPontr:EPontr).EQ.Dollar) GO TO 109                       00000186
      IF(IBuf(EPontr:EPontr).EQ.Amsand) GO TO 109                       00000187
      IF(IBuf(SPontr:EPontr).EQ.DEnd) GO TO 109                         00000188
      IF(IBuf(SPontr:EPontr).EQ.AEnd) GO TO 109                         00000189
      GO TO 107                                                         00000190
109   REWIND LUnit                                                      00000191
      RETURN                                                            00000192
C                                                                       00000193
C                                                                       00000194
C***********************************************************************00000195
C*                                                                     *00000196
C*    CLOSE THE TEMPORARY SCRATCH FILE ON LOGICAL UNIT NUMBER UNIT     *00000197
C*                                                                     *00000198
C***********************************************************************00000199
C                                                                       00000200
C                                                                       00000201
      ENTRY NDRUSE(*,*)                                                 00000202
      CLOSE(UNIT=LUnit,STATUS='DELETE',ERR=114)                         00000203
      RETURN                                                            00000204
C                                                                       00000205
C                                                                       00000206
C***********************************************************************00000207
C*                                                                     *00000208
C*                           ERROR MESSAGES                            *00000209
C*                                                                     *00000210
C***********************************************************************00000211
C                                                                       00000212
C                                                                       00000213
110   WRITE(UNIT=6,FMT=202)                                             00000214
      RETURN 2                                                          00000215
111   WRITE(UNIT=6,FMT=203)                                             00000216
      RETURN 2                                                          00000217
112   WRITE(UNIT=6,FMT=204)                                             00000218
      CALL CBUS06(6,NBuf,*117)                                          00000219
      WRITE(UNIT=6,FMT=205)IBS                                          00000220
      RETURN 2                                                          00000221
113   WRITE(UNIT=6,FMT=206)LUnit                                        00000222
      RETURN 2                                                          00000223
114   WRITE(UNIT=6,FMT=207)LUnit                                        00000224
      RETURN 2                                                          00000225
115   WRITE(UNIT=6,FMT=208)LUnit                                        00000226
      RETURN 2                                                          00000227
116   WRITE(UNIT=6,FMT=209)LUnit                                        00000228
      RETURN 2                                                          00000229
117   WRITE(UNIT=6,FMT=210)                                             00000230
      RETURN 2                                                          00000231
C                                                                       00000232
C                                                                       00000233
C***********************************************************************00000234
C*                                                                     *00000235
C*                          FORMAT STATEMENTS                          *00000236
C*                                                                     *00000237
C***********************************************************************00000238
C                                                                       00000239
C                                                                       00000240
```

```
201   FORMAT(A80)                                                       00000241
202   FORMAT('SUBROUTINE CBUS04 WAS CALLED FROM SUBROUTINE NDRUS')      00000242
203   FORMAT(/,'ERROR IN SUBROUTINE NDRUS: EMPTY NAMELIST GROUP-NAME CHA00000243
     >RACTER',/,'BUFFER, NBuf')                                         00000244
204   FORMAT(/,'ERROR IN SUBROUTINE NDRUS: THE LENGTH OF THE NAMELIST GR00000245
     >OUP-NAME NBuf =')                                                 00000246
205   FORMAT('PLUS 2 EXCEEDS THE INPUT BUFFER SIZE, IBS =',I3)          00000247
206   FORMAT(/,'ERROR IN SUBROUTINE NDRUS: INQUIRE ERROR ON UNIT ',I1)  00000248
207   FORMAT(/,'ERROR IN SUBROUTINE NDRUS: CLOSE ERROR ON UNIT ',I1,/,'S00000249
     >TATUS = "DELETE"')                                                00000250
208   FORMAT(/,'ERROR IN SUBROUTINE NDRUS: OPEN ERROR ON UNIT ',I1,', ST00000251
     >ATUS = "SCRATCH"')                                                00000252
209   FORMAT(/,'ERROR IN SUBROUTINE NDRUS: WRITE ERROR ON UNIT ',I1)    00000253
210   FORMAT('SUBROUTINE CBUS06 WAS CALLED FROM SUBROUTINE NDRUS')      00000254
      END                                                               00000255
```

```
      SUBROUTINE NDWUS(NBuf,KUnit,*)                                    00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*         NAMELIST-DIRECTED WRITE UTILITY SUBROUTINE (NDWUS)          *00000006
C*                                                                     *00000007
C*                     REVISION DATE: 23 MARCH 1999                    *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C***********************************************************************00000012
C*                                                                     *00000013
C*  SUBROUTINE NDWUS EXECUTES AN INTELLIGENT NAMELIST-DIRECTED WRITE   *00000014
C*  PROCESS FOR  PROGRAM PSCCPP  WITH OUTPUT TO THE  HIGH LEVEL PLOT   *00000015
C*  COMMAND FILE ON LOGICAL UNIT NUMBER LUnit.                          00000016
C*                                                                     *00000017
C* PARAMETERS:                                                         *00000018
C*                                                                     *00000019
C* FieldL = FIELD LENGTH                                               *00000020
C* OBS    = OUTPUT CHARACTER BUFFER SIZE                               *00000021
C*                                                                     *00000022
C* VARIABLES:                                                          *00000023
C*                                                                     *00000024
C* AFL    = AVAILABLE FIELD LENGTH                                     *00000025
C* CBuf   = CHARACTER BUFFER                                           *00000026
C* DBuf   = DOUBLE PRECISION ARRAY BUFFER                              *00000027
C* IBuf   = INTEGER ARRAY BUFFER                                       *00000028
C* N      = NUMBER OF ELEMENTS IN RBuf OR IBuf                         *00000029
C* N1     = STARTING ELEMENT IN RBuf OR IBuf                           *00000030
C* N2     = ENDING ELEMENT IN RBuf OR IBuf                             *00000031
C* NBuf   = NAMELIST GROUP-NAME CHARACTER BUFFER                       *00000032
C* NNFL   = NAMELIST NAME FIELD LENGTH                                 *00000033
C* OBuf   = OUTPUT CHARACTER BUFFER                                    *00000034
C* RBuf   = REAL ARRAY BUFFER                                          *00000035
C* RFL    = REQUIRED FIELD LENGTH                                      *00000036
C* LUnit  = OUTPUT FILE LOGICAL UNIT NUMBER                            *00000037
C* VBuf   = VARIABLE NAME CHARACTER BUFFER                             *00000038
C* VNFL   = VARIABLE NAME FIELD LENGTH                                 *00000039
C*                                                                     *00000040
C***********************************************************************00000041
C                                                                       00000042
C                                                                       00000043
      CHARACTER Apos*2,CBuf*(*),Dollar*1,Equal*1,NBuf*(*),OBuf*75,      00000044
     >VBuf*(*)                                                          00000045
C                                                                       00000046
      REAL*8 DBuf                                                       00000047
C                                                                       00000048
      INTEGER AFL,EPontr,FieldL,OBS,RFL,SPontr,TPontr,VNFL              00000049
C                                                                       00000050
      PARAMETER (FieldL=15,OBS=75)                                      00000051
C                                                                       00000052
      DIMENSION DBuf(N),IBuf(N),RBuf(N)                                 00000053
C                                                                       00000054
      EQUIVALENCE (AFL,NNFL,VNFL)                                       00000055
C                                                                       00000056
      SAVE AFL,Apos,Dollar,EPontr,Equal,ICV,LUnit,OBuf,RFL,SPontr,      00000057
     >TPontr,VNFL                                                       00000058
C                                                                       00000059
      DATA Apos/"'","/,Dollar/'$'/,Equal/'='/                           00000060
```

```
C                                                                       00000061
C                                                                       00000062
C***********************************************************************00000063
C*                                                                     *00000064
C*                   OPEN THE NAMELIST OUTPUT BUFFER                   *00000065
C*                                                                     *00000066
C***********************************************************************00000067
C                                                                       00000068
C                                                                       00000069
      LUnit=KUnit                                                       00000070
      CALL CBUS03(NBuf)                                                 00000071
      CALL CBUS01(NBuf,L)                                               00000072
      NNFL=FieldL                                                       00000073
      IF((L+2).GT.NNFL) GO TO 124                                       00000074
      CALL CBUS07(OBuf)                                                 00000075
      SPontr=2                                                          00000076
      EPontr=2                                                          00000077
      OBuf(SPontr:EPontr)=Dollar                                        00000078
      SPontr=EPontr+1                                                   00000079
      EPontr=EPontr+L                                                   00000080
      OBuf(SPontr:EPontr)=NBuf(1:L)                                     00000081
      TPontr=FieldL                                                     00000082
      CALL CBUS01(OBuf,L)                                               00000083
      VNFL=TPontr-L-1                                                   00000084
      RETURN                                                            00000085
C                                                                       00000086
C                                                                       00000087
C***********************************************************************00000088
C*                                                                     *00000089
C*         INSERT A CHARACTER VARIABLE INTO THE OUTPUT BUFFER          *00000090
C*                                                                     *00000091
C***********************************************************************00000092
C                                                                       00000093
C                                                                       00000094
      ENTRY NDWUSC(VBuf,CBuf,*)                                         00000095
      CALL CBUS03(CBuf)                                                 00000096
      CALL CBUS01(CBuf,L)                                               00000097
      RFL=L+4                                                           00000098
      ICV=1                                                             00000099
      GO TO 118                                                         00000100
101   CALL CBUS01(CBuf,L)                                               00000101
      AFL=0                                                             00000102
102   TPontr=TPontr+FieldL                                              00000103
      AFL=AFL+FieldL                                                    00000104
      IF(RFL.GT.AFL) GO TO 102                                          00000105
      IF(TPontr.GT.OBS) TPontr=OBS                                      00000106
      SPontr=TPontr-L-2                                                 00000107
      EPontr=SPontr                                                     00000108
      OBuf(SPontr:EPontr)=Apos(1:1)                                     00000109
      SPontr=EPontr+1                                                   00000110
      EPontr=TPontr-2                                                   00000111
      OBuf(SPontr:EPontr)=CBuf(1:L)                                     00000112
      SPontr=TPontr-1                                                   00000113
      EPontr=TPontr                                                     00000114
      OBuf(SPontr:EPontr)=Apos                                          00000115
      VNFL=0                                                            00000116
      RETURN                                                            00000117
C                                                                       00000118
C                                                                       00000119
C***********************************************************************00000120
```

```
C*                                                                     *00000121
C*           INSERT AN INTEGER ARRAY INTO THE OUTPUT BUFFER            *00000122
C*                                                                     *00000123
C**********************************************************************00000124
C                                                                       00000125
C                                                                       00000126
      ENTRY NDWUSI(VBuf,N,N1,N2,IBuf,*)                                 00000127
      RFL=FieldL                                                        00000128
      ICV=2                                                             00000129
      GO TO 118                                                         00000130
103   DO 107 I=N1,N2                                                   00000131
104   TPontr=TPontr+FieldL                                              00000132
      IF(TPontr.LE.OBS) GO TO 106                                       00000133
      JCV=1                                                             00000134
      GO TO 123                                                         00000135
105   GO TO 104                                                         00000136
106   SPontr=TPontr-FieldL+1                                            00000137
      EPontr=TPontr                                                     00000138
107   WRITE(OBuf(SPontr:EPontr),FMT=201)IBuf(I)                         00000139
      VNFL=0                                                            00000140
      RETURN                                                            00000141
C                                                                       00000142
C                                                                       00000143
C**********************************************************************00000144
C*                                                                    *00000145
C*             INSERT A REAL ARRAY INTO THE OUTPUT BUFFER             *00000146
C*                                                                    *00000147
C**********************************************************************00000148
C                                                                       00000149
C                                                                       00000150
      ENTRY NDWUSR(VBuf,N,N1,N2,RBuf,*)                                 00000151
      RFL=FieldL                                                        00000152
      ICV=3                                                             00000153
      GO TO 118                                                         00000154
108   DO 112 I=N1,N2                                                   00000155
109   TPontr=TPontr+FieldL                                              00000156
      IF(TPontr.LE.OBS) GO TO 111                                       00000157
      JVC=2                                                             00000158
      GO TO 123                                                         00000159
110   GO TO 109                                                         00000160
111   SPontr=TPontr-FieldL+1                                            00000161
      EPontr=TPontr                                                     00000162
112   WRITE(OBuf(SPontr:EPontr),FMT=202)RBuf(I)                         00000163
      VNFL=0                                                            00000164
      RETURN                                                            00000165
C                                                                       00000166
C                                                                       00000167
C**********************************************************************00000168
C*                                                                    *00000169
C*       INSERT A DOUBLE PRECISION ARRAY INTO THE OUTPUT BUFFER       *00000170
C*                                                                    *00000171
C**********************************************************************00000172
C                                                                       00000173
C                                                                       00000174
      ENTRY NDWUSD(VBuf,N,N1,N2,DBuf,*)                                 00000175
      RFL=FieldL                                                        00000176
      ICV=4                                                             00000177
      GO TO 118                                                         00000178
113   DO 117 I=N1,N2                                                   00000179
114   TPontr=TPontr+FieldL                                              00000180
```

```
      IF(TPontr.LE.OBS) GO TO 116                                       00000181
      JVC=3                                                             00000182
      GO TO 123                                                         00000183
115   GO TO 114                                                         00000184
116   SPontr=TPontr-FieldL+1                                            00000185
      EPontr=TPontr                                                     00000186
117   WRITE(OBuf(SPontr:EPontr),FMT=202)DBuf(I)                         00000187
      VNFL=0                                                            00000188
      RETURN                                                            00000189
C                                                                       00000190
C                                                                       00000191
C*********************************************************************00000192
C*                                                                    *00000193
C*            INSERT A VARIABLE NAME INTO THE OUTPUT BUFFER           *00000194
C*                                                                    *00000195
C*********************************************************************00000196
C                                                                       00000197
C                                                                       00000198
118   CALL CBUS03(VBuf)                                                 00000199
      CALL CBUS01(VBuf,L)                                               00000200
      IF((L+2)+RFL.GT.OBS) RETURN 1                                     00000201
119   IF((L+2).LE.VNFL) GO TO 120                                       00000202
      TPontr=TPontr+FieldL                                              00000203
      VNFL=VNFL+FieldL                                                  00000204
      GO TO 119                                                         00000205
120   IF(TPontr+RFL.LE.OBS) GO TO 122                                   00000206
      JVC=4                                                             00000207
      GO TO 123                                                         00000208
121   GO TO 119                                                         00000209
122   SPontr=TPontr-L-1                                                 00000210
      EPontr=TPontr-2                                                   00000211
      OBuf(SPontr:EPontr)=VBuf(1:L)                                     00000212
      SPontr=EPontr+2                                                   00000213
      EPontr=TPontr                                                     00000214
      OBuf(SPontr:EPontr)=Equal                                         00000215
      GO TO (101,103,108,113),ICV                                       00000216
C                                                                       00000217
C                                                                       00000218
C*********************************************************************00000219
C*                                                                    *00000220
C*                       FLUSH THE OUTPUT BUFFER                      *00000221
C*                                                                    *00000222
C*********************************************************************00000223
C                                                                       00000224
C                                                                       00000225
123   WRITE(UNIT=LUnit,Fmt=203,ERR=129)OBuf                             00000226
      CALL CBUS07(OBuf)                                                 00000227
      TPontr=0                                                          00000228
      VNFL=0                                                            00000229
      GO TO (105,110,115,121),JVC                                       00000230
C                                                                       00000231
C                                                                       00000232
C*********************************************************************00000233
C*                                                                    *00000234
C*                  CLOSE THE NAMELIST OUTPUT BUFFER                  *00000235
C*                                                                    *00000236
C*********************************************************************00000237
C                                                                       00000238
C                                                                       00000239
      ENTRY NDWUSE(*)                                                   00000240
```

```
      CALL CBUS01(OBuf,L)                                                00000241
      SPontr=L                                                           00000242
      EPontr=L                                                           00000243
      OBuf(SPontr:EPontr)=Dollar                                         00000244
      WRITE(UNIT=LUnit,Fmt=203,ERR=129)OBuf                              00000245
      IF(LUnit.EQ.6) WRITE(UNIT=LUnit,Fmt=204,ERR=129)                   00000246
      RETURN                                                             00000247
C                                                                        00000248
C                                                                        00000249
C*************************************************************************00000250
C*                                                                       *00000251
C*                          ERROR MESSAGES                               *00000252
C*                                                                       *00000253
C*************************************************************************00000254
C                                                                        00000255
C                                                                        00000256
124   WRITE(UNIT=6,FMT=205)                                              00000257
      CALL CBUS06(6,NBuf,*130)                                           00000258
      WRITE(UNIT=6,FMT=206)NNFL                                          00000259
      RETURN 1                                                           00000260
125   WRITE(UNIT=6,FMT=207)                                              00000261
      CALL CBUS06(6,VBuf,*130)                                           00000262
      WRITE(UNIT=6,FMT=208)                                              00000263
      CALL CBUS06(6,CBuf,*130)                                           00000264
      WRITE(UNIT=6,FMT=209)OBS                                           00000265
      RETURN 1                                                           00000266
126   WRITE(UNIT=6,FMT=207)                                              00000267
      CALL CBUS06(6,VBuf,*130)                                           00000268
      WRITE(UNIT=6,FMT=210)OBS                                           00000269
      RETURN 1                                                           00000270
127   WRITE(UNIT=6,FMT=207)                                              00000271
      CALL CBUS06(6,VBuf,*130)                                           00000272
      WRITE(UNIT=6,FMT=211)OBS                                           00000273
      RETURN 1                                                           00000274
128   WRITE(UNIT=6,FMT=207)                                              00000275
      CALL CBUS06(6,VBuf,*130)                                           00000276
      WRITE(UNIT=6,FMT=212)OBS                                           00000277
      RETURN 1                                                           00000278
129   WRITE(UNIT=6,FMT=213)LUnit                                         00000279
      RETURN 1                                                           00000280
130   WRITE(UNIT=6,FMT=214)                                              00000281
131   RETURN 1                                                           00000282
C                                                                        00000283
C                                                                        00000284
C*************************************************************************00000285
C*                                                                       *00000286
C*                        FORMAT STATEMENTS                              *00000287
C*                                                                       *00000288
C*************************************************************************00000289
C                                                                        00000290
C                                                                        00000291
201   FORMAT(I14,',')                                                    00000292
202   FORMAT(E14.6,',')                                                  00000293
203   FORMAT(A75)                                                        00000294
204   FORMAT()                                                           00000295
205   FORMAT(/,'ERROR IN SUBROUTINE NDWUS: THE LENGTH OF THE NAMELIST GR00000296
     >OUP-NAME NBuf =')                                                  00000297
206   FORMAT('EXCEEDS THE NAMELIST NAME FIELD LENGTH =',I3)              00000298
207   FORMAT(/,'ERROR IN SUBROUTINE NDWUS: THE LENGTH OF THE VARIABLE NA00000299
     >ME VBuf =')                                                        00000300
```

```
208   FORMAT('PLUS THE LENGTH OF THE CHARACTER VARIABLE CBuf =')        00000301
209   FORMAT('EXCEEDS THE OUTPUT BUFFER SIZE, OBS =',I3)                00000302
210   FORMAT('PLUS THE FIELD LENGTH FOR AN INTEGER VARIABLE EXCEEDS THE 00000303
     >OUTPUT BUFFER',/,'SIZE, OBS =',I3)                                00000304
211   FORMAT('PLUS THE FIELD LENGTH FOR A REAL VARIABLE EXCEEDS THE OUTP00000305
     >UT BUFFER',/,'SIZE, OBS =',I3)                                    00000306
212   FORMAT('PLUS THE FIELD LENGTH FOR A DOUBLE PRECISION VARIABLE EXCE00000307
     >EDS THE OUTPUT BUFFER',/,'SIZE, OBS =',I3)                        00000308
213   FORMAT(/,'ERROR IN SUBROUTINE NDWUS: WRITE ERROR ON UNIT ',I1)    00000309
214   FORMAT('SUBROUTINE CBUS06 WAS CALLED FROM SUBROUTINE NDWUS')      00000310
      END                                                               00000311
```

```
      SUBROUTINE YNOUS(*,*,*)                                           00000001
C                                                                       00000002
C                                                                       00000003
C***********************************************************************00000004
C*                                                                     *00000005
C*               YES/NO/OTHER UTILITY SUBROUTINE (YNOUS)               *00000006
C*                                                                     *00000007
C*                  REVISION DATE: 29 SEPTEMBER 2000                   *00000008
C*                                                                     *00000009
C***********************************************************************00000010
C                                                                       00000011
C***********************************************************************00000012
C*                                                                     *00000013
C* SUBROUTINE YNOUS READS ONE BYTE FROM UNIT 5  ANTICIPATING A 'Y' OR  *00000014
C* 'y' YES RESPONSE OR ALTERNATIVELY A 'N' OR 'n' NO RESPONSE.  A YES  *00000015
C* RESPONSE  RESULTS  IN A  RETURN 1;  A NO  RESPONSE  RESULTS  IN  A  *00000016
C* RETURN 2.  ALL OTHER RESPONSES RESULT IN A RETURN 3.                *00000017
C*                                                                     *00000018
C***********************************************************************00000019
C                                                                       00000020
C                                                                       00000021
      CHARACTER CCV*1,No*1,Switch*1,Yes*1                               00000022
C                                                                       00000023
      SAVE No,Yes                                                       00000024
C                                                                       00000025
      DATA No/'N'/,Switch/'U'/,Yes/'Y'/                                 00000026
C                                                                       00000027
C                                                                       00000028
C***********************************************************************00000029
C*                                                                     *00000030
C*                READ ONE BYTE AND COMPARE WITH Yes/No                *00000031
C*                                                                     *00000032
C***********************************************************************00000033
C                                                                       00000034
C                                                                       00000035
      READ(UNIT=5,FMT=201)CCV                                           00000036
      CALL CBUS04(CCV,Switch,*101)                                      00000037
      IF(CCV.EQ.Yes) RETURN 1                                           00000038
      IF(CCV.EQ.No) RETURN 2                                            00000039
      RETURN 3                                                          00000040
C                                                                       00000041
C                                                                       00000042
C***********************************************************************00000043
C*                                                                     *00000044
C*                           ERROR MESSAGES                            *00000045
C*                                                                     *00000046
C***********************************************************************00000047
C                                                                       00000048
C                                                                       00000049
101   WRITE(UNIT=6,FMT=202)                                             00000050
      RETURN 3                                                          00000051
C                                                                       00000052
C***********************************************************************00000053
C*                                                                     *00000054
C*                          FORMAT STATEMENTS                          *00000055
C*                                                                     *00000056
C***********************************************************************00000057
C                                                                       00000058
C                                                                       00000059
201   FORMAT(A1)                                                        00000060
```

```
202   FORMAT('SUBROUTINE CBUS04 WAS CALLED FROM SUBROUTINE YNOUS')      00000061
      END                                                               00000062
```

APPENDIX D
EXAMPLE 1

In this example, the LSPRWC code was applied to a set of observations taken for an object accelerating from rest at a constant 9.81 m/s^2, the acceleration of gravity. The true behavior for the object, in terms of displacement as a function of time, is given by

$$\frac{d^2x}{dt^2} = \text{constant} \tag{1}$$

$$= a, \tag{2}$$

and integrating equation (1) twice gives

$$\frac{dx}{dt} = v_0 + at, \tag{3}$$

$$= v(t), \tag{4}$$

and

$$x(t) = x_0 + v_0 t + \frac{1}{2} a t^2 \tag{5}$$

where

a = acceleration,
t = time,
v = velocity,
v_0 = initial velocity,
x = displacement,
x_0 = initial position.

Then for

$$x_0 = 0, \tag{6}$$

$$v_0 = 0, \tag{7}$$

equations (3), (4), and (5) reduce to

$$v(t) = at \tag{8}$$

and

$$x(t) = \frac{1}{2} a t^2. \tag{9}$$

The observations for this example are given in Table D-1 along with the true values for displacement, velocity, and acceleration. Figures D-1 through 3 present *X Window System* screen shots from LSPRWC code execution using this data set.

Table D-1. Trajectory Data

Time (s)	True Position (m)	True Velocity (m/s)	True Acceleration (m/s**2)	Measured Position (m)
0.000000E+00	0.000000E+00	0.000000E+00	0.981000E+01	0.000000E+00
0.100000E+00	0.490500E-01	0.981000E+00	0.981000E+01	0.841678E+00
0.200000E+00	0.196200E+00	0.196200E+01	0.981000E+01	0.262622E+00
0.300000E+00	0.441450E+00	0.294300E+01	0.981000E+01	-0.293670E+00
0.400000E+00	0.784800E+00	0.392400E+01	0.981000E+01	0.177628E+01
0.500000E+00	0.122625E+01	0.490500E+01	0.981000E+01	0.179120E+01
0.600000E+00	0.176580E+01	0.588600E+01	0.981000E+01	0.223221E+01
0.700000E+00	0.240345E+01	0.686700E+01	0.981000E+01	0.211730E+01
0.800000E+00	0.313920E+01	0.784800E+01	0.981000E+01	0.322466E+01
0.900000E+00	0.397305E+01	0.882900E+01	0.981000E+01	0.306116E+01
0.100000E+01	0.490500E+01	0.981000E+01	0.981000E+01	0.466451E+01
0.110000E+01	0.593505E+01	0.107910E+02	0.981000E+01	0.669913E+01
0.120000E+01	0.706320E+01	0.117720E+02	0.981000E+01	0.781203E+01
0.130000E+01	0.828945E+01	0.127530E+02	0.981000E+01	0.790575E+01
0.140000E+01	0.961380E+01	0.137340E+02	0.981000E+01	0.105721E+02
0.142784E+01	0.100000E+02	0.140071E+02	0.981000E+01	0.920335E+01

```
   PROGRAM LSPRWC IS AN INTERACTIVE FORTRAN PROGRAM TO PERFORM A LEAST
SQUARES POLYNOMIAL REGRESSION WITH CONTRAINTS; THAT IS, A SET OF X-Y DATA
POINTS IS CURVE FIT WITH AN NP ORDER POLYNOMIAL OF THE FORM

               P(X)=B0+B1*X+B2*X**2+B3*X**3+....+BNP*X**NP

WITH ANY POLYNOMIAL DERIVATIVES, ZERO THROUGH NP, SPECIFIED AT GIVEN X
LOCATIONS.  THE PROCEDURE FOLLOWED IS THE METHOD OF LEAST SQUARES USING
UNDETERMINED LAGRANGE MULTIPLIERS.

   AS AN INTERACTIVE PROGRAM, LSPRWC IS SELF-EXPLANATORY AND PROMPTS FOR THE
NECESSARY INFORMATION.  THE X-Y DATA TO BE FITTED MAY BE ENTERED BY NAMELIST
OR READ FROM A FORMATTED DISC FILE.  PROGRAM LSPRWC WILL ALSO EVALUATE THE
RESULTANT LEAST SQUARES POLYNOMIAL AT PRESCRIBED VALUES OF X WHICH, AGAIN,
MAY BE ENTERED BY NAMELIST OR READ FROM A FORMATTED DISK FILE.

                 - ENTER/RETURN TO CONTINUE -


SELECT THE SOURCE OF INPUT FOR THE X-Y DATA TO BE FITTED FROM
THE FOLLOWING LIST:

1, FOR KEYBOARD INPUT VIA NAMELIST
2, FOR FORMATTED DISK FILE INPUT

NOTE: THE X-Y DATA MUST BE MONATONICALLY INCREASING IN X.
2

DATA SETS ARE INPUT FROM FORMATTED DISK FILES AS (X,Y) PAIRS WHERE:

X      = X VALUE
Y      = Y VALUE

INPUT THE FILE NAME OF THE FORMATTED DISK FILE DATA SET.
trajectory.dat

INPUT THE DATA FILE FORMAT (INCLUDE PARENTHESES)
NOTE: AN EXAMPLE FORMAT IS "(2E15.6)"
     ENTER"(*)" FOR A FREE FIELD READ (DEFAULT FORMAT)
(E15.6,T61,E15.6)

SHOULD THE X-Y DATA BE DISPLAYED FOR VERIFICATION? (Y/N)
y

        NO.            X                    Y
          1    0.0000000000000E+00    0.0000000000000E+00
          2    1.0000000000000E-01    8.4167800000000E-01
          3    2.0000000000000E-01    2.6262200000000E-01
          4    3.0000000000000E-01   -2.9367000000000E-01
          5    4.0000000000000E-01    1.7762800000000E+00
          6    5.0000000000000E-01    1.7912000000000E+00
          7    6.0000000000000E-01    2.2322100000000E+00
          8    7.0000000000000E-01    2.1173000000000E+00
          9    8.0000000000000E-01    3.2246600000000E+00
         10    9.0000000000000E-01    3.0611600000000E+00
         11    1.0000000000000E+00    4.6645100000000E+00
         12    1.1000000000000E+00    6.6991300000000E+00
         13    1.2000000000000E+00    7.8120300000000E+00
         14    1.3000000000000E+00    7.9057500000000E+00
         15    1.4000000000000E+00    1.0572100000000E+01
         16    1.4278400000000E+00    9.2033500000000E+00

                 - ENTER/RETURN TO CONTINUE -
```

Figure D-1 LSPRWC Screen Shot—Part 1

```
ARE CONSTRAINTS DESIRED? (Y/N)
N

INPUT THE POLYNOMIAL ORDER BY NAMELIST WHERE:

NP    = THE POLYNOMIAL ORDER

NOTE: NP MUST BE IN THE RANGE OF 0 TO 9.
      THERE MUST BE AT LEAST NP+NCONST+1 X-Y DATA POINTS.
      THE MAXIMUM VALUE FOR NP IS     9.

CURRENT VALUES ARE:
 $PARM     NP =             3$

Np=2$
      LEAST SQUARES POLYNOMIAL

                P(X)=B(0)+B(1)*X+B(2)*X**2+....+B(NP)*X**NP

                   I            B(I)

                   0      2.7806885044562E-01
                   1     -3.2364562759090E-01
                   2      5.0277277787627E+00

   THE STANDARD DEVIATION FOR THIS POLYNOMIAL OF ORDER   2 IS  7.17016E-01

                - ENTER/RETURN TO CONTINUE -


SHOULD DATA POINTS BE PRESCRIBED FOR EVALUATION OF THE LEAST SQUARES
POLYNOMIALS? (Y/N)
Y

SELECT THE SOURCE OF INPUT FOR THE X DATA TO BE EVALUATED FROM THE FOLLOWING
LIST:

1, FOR KEYBOARD INPUT VIA NAMELIST
2, FOR FORMATTED DISK FILE INPUT
3, FOR INPUT OF MINIMUM, MAXIMUM, AND INTERVAL VALUES
3

INPUT THE X DATA MAXIMUM, MINIMUM, AND INTERVAL VALUES BY NAMELIST WHERE:

XINT   = X DATA POINT INTERVAL
XMAX   = MAXIMUM X DATA VALUE
XMIN   = MINIMUM X DATA VALUE

CURRENT VALUES ARE:
 $PARM   XINT =  0.142784E-01,         XMAX =  0.142784E+01,
         XMIN =  0.000000E+00$



SHOULD THE X-Y DATA BE DISPLAYED FOR VERIFICATION? (Y/N)
n

SHOULD THE RESULTS OF THIS RUN BE QUICK-PLOTTED? (Y/N)
N
```

Figure D-2. LSPRWC Screen Shot—Part 2

```
ENTER:
1, TO RESTART THE PROGRAM
2, TO CHANGE THE CONSTRAINTS
3, TO CHANGE THE POLYNOMIAL ORDER
4, TO CHANGE THE PRESCRIBED X VALUES FOR EVALUATION OF THE POLYNOMIAL
5, TO PLOT THE RESULTS
6, TO SAVE THE RESULTS ON A FORMATTED DISC FILE
7, TO STOP
6

INPUT THE FILE NAME OF THE FORMATTED DISK FILE.
np2.dat

SELECT THE TYPE OF OUTPUT FOR THE FORMATTED DISK FILE FROM THE FOLLOWING LIST:
1, FOR ALL INPUT DATA AND RESULTS
2, FOR ONLY THE EVALUATED DATA
2

INPUT THE EVALUATED DATA VARIABLE LIST FOR OUTPUT BY NAMELIST WHERE:

"X"    = X VALUES
"0"    = 0th DERIVATIVE OF Y AT X
"1"    = 1th DERIVATIVE OF Y AT X
"2"    = 2th DERIVATIVE OF Y AT X
"R"    = RADIUS OF CURVATURE AT X
"S"    = ARC LENGTH

NOTE: VARIABLES WILL BE LISTED IN THE ORDER OF INPUT

CURRENT VALUES ARE:

$PARM AList= "X","0"$

AList="X","0","1","2"$

INPUT THE DATA FILE FORMAT (INCLUDE PARENTHESES)

NOTE: AN EXAMPLE FORMAT IS "(F15.7,E15.6)"
      THE DEFAULT FORMAT IS:
(13E15.6)


ENTER:
1, TO RESTART THE PROGRAM
2, TO CHANGE THE CONSTRAINTS
3, TO CHANGE THE POLYNOMIAL ORDER
4, TO CHANGE THE PRESCRIBED X VALUES FOR EVALUATION OF THE POLYNOMIAL
5, TO PLOT THE RESULTS
6, TO SAVE THE RESULTS ON A FORMATTED DISC FILE
7, TO STOP
7
```

Figure D-3. LSPRWC Screen Shot—Part 3

Following along through Figure D-1, the user was presented with an introduction to LSPRWC and then asked for the data source. Here the source was selected as a formatted disk file followed by the file name and read format. The (x, y) data pairs—time and measured position—were displayed for verification and match the values given in Table D-1.

Moving on through Figure D-2, the code asked if problem constraints were desired and none were selected. The user was then asked to enter the polynomial order which was set to $n_p = 2$ by means of NAMELIST. With the problem thus fully defined, program LSPRWC

returned values for the coefficients of the least squares regression polynomial, b_0, b_1, and b_2, and the standard deviation for the fit to the (x, y) data pairs as input. This 2nd order regression polynomial was then evaluated at specific values of x, in this case time, using the minimum, maximum, and interval option.

Following through Figure D-3, menu options were chosen to output the evaluated data to a formatted disk file writing, in order, each value of x, y, and the first and second derivatives, $\frac{dy}{dx}$, and $\frac{d^2y}{dx^2}$. With that, the LSPRWC code menu option was selected for program termination.

The results from this particular LSPRWC run are shown in Figure D-4 as plots of displacement and velocity as a function of time along with the true values and the measurements of Table D-1. The 2nd order least squares regression polynomial fits quite well in this case, as might be expected considering that the true solution for displacement, given by equation (9), is 2nd order in time.

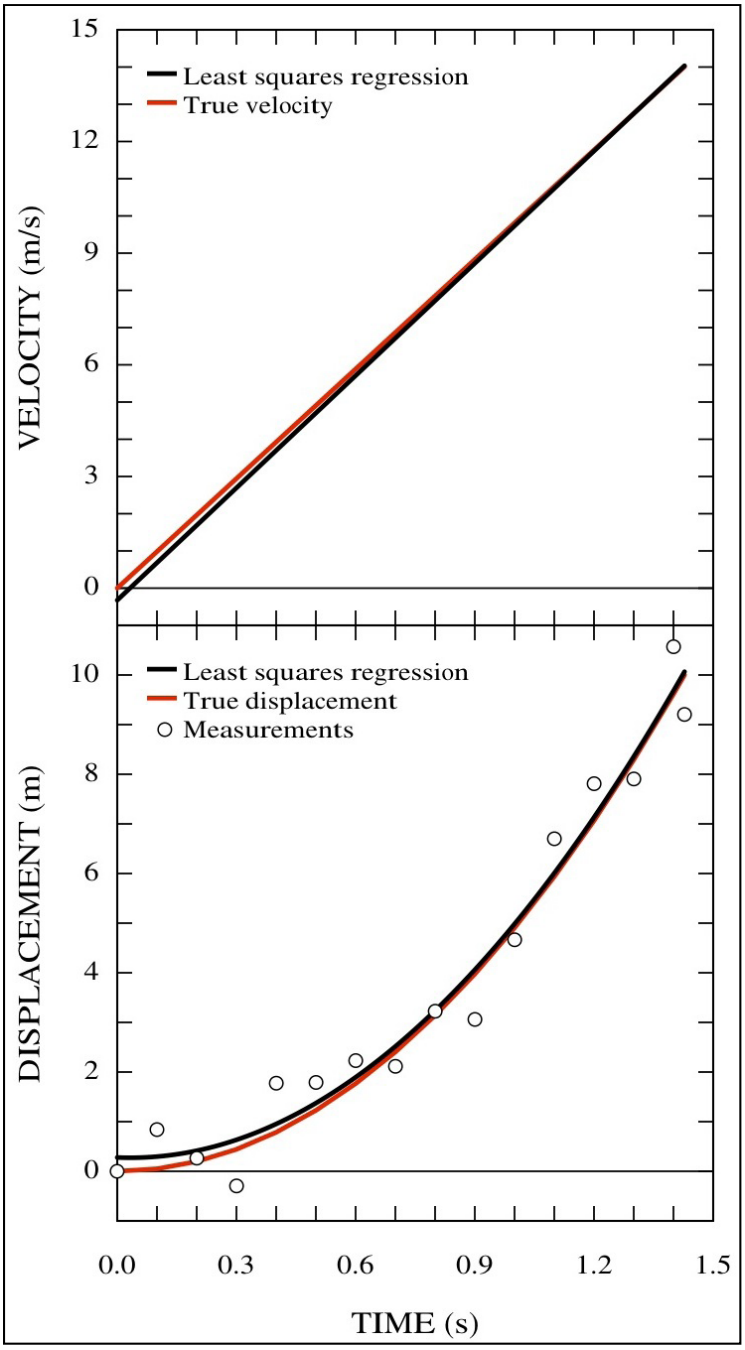

Figure D-4. Least Squares Polynomial Regression for $n_p = 2$

The LSPRWC code could have been run with any choice of polynomial order from 0 through 9 as was done to produce the results of Figure D-5. This plot of displacement as a function of time shows a reasonable fit for the regression polynomials for $n_p = 2$ and 3. Clearly, the representation begins to degrade with polynomial orders of 4 and greater.

Section V. LIMITATIONS notes that the LSPRWC code limits the polynomial order such that $0 \leq n_p \leq 9$. This example serves as excellent justification for this limitation since the

9th order least squares regression polynomial gives the best fit to the measured data in Figure D-5 yet the polynomial representation is quite unlike the true solution.

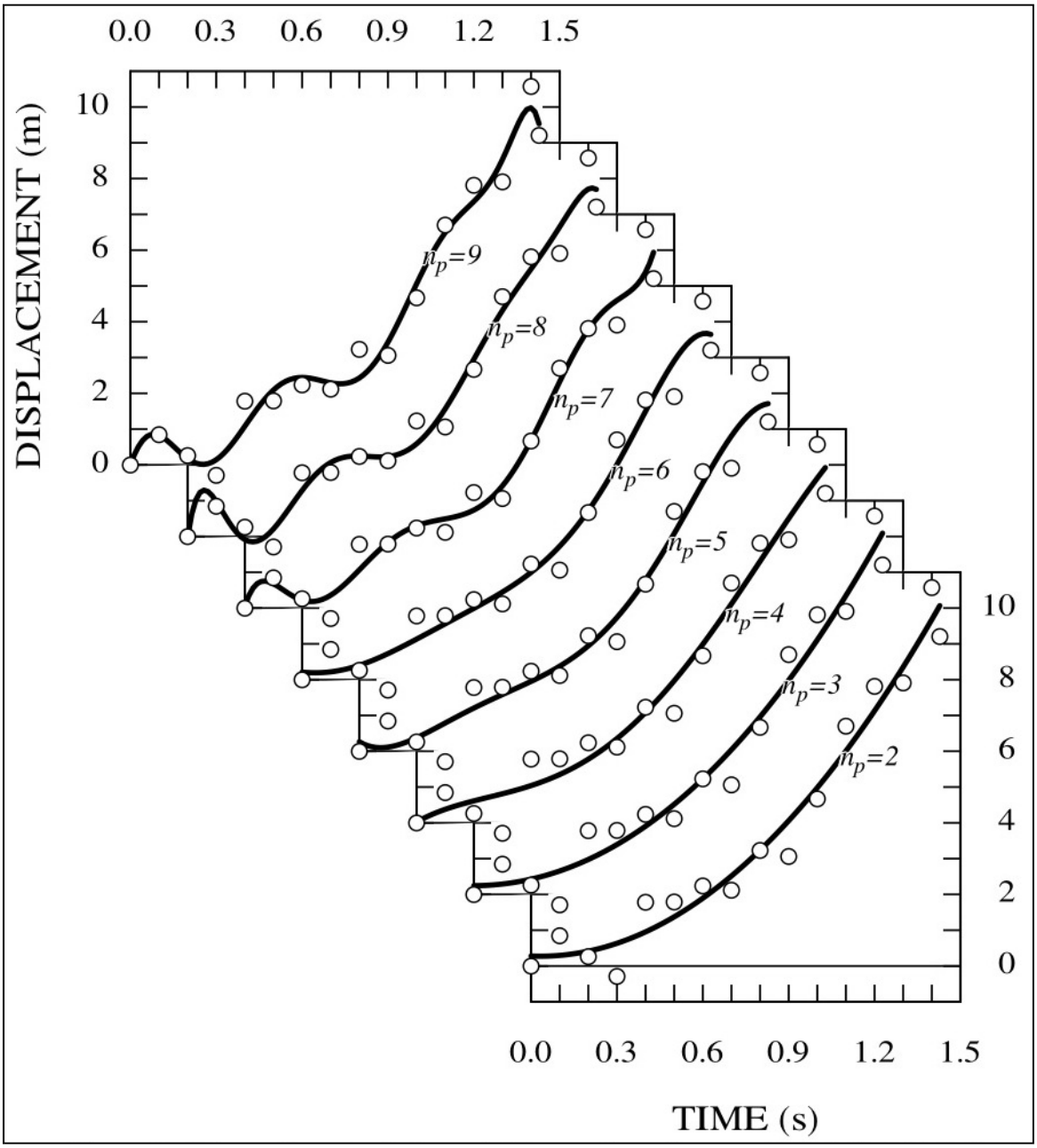

Figure D-5. Least Squares Polynomial Regressions for n_p = 2, 3, 4, 5, 6, 7, 8, 9

Examining once again the plots of displacement and velocity as a function of time in Figure D-4, it is obvious that this 2nd order regression polynomial does not satisfy either equation (6) or (7); that is to say, the displacement and velocity are non-zero at time equal zero. Furthermore, the polynomial coefficients b_0 and b_1 are non-zero as shown in Figure D-2. Still, the acceleration $a = 2 \times b_2 = 10.055$ m/s^2 is reasonably close to the true value of 9.81 m/s^2.

Since the initial displacement and velocity are known, these could be used as constraints with the LSPRWC code to improve the regression. Figures D-6 through 9 present *X Window System* screen shots from LSPRWC code execution using again the observations of Table D-1 but with these constraints.

```
   AS AN INTERACTIVE PROGRAM, LSPRWC IS SELF-EXPLANATORY AND PROMPTS FOR THE
NECESSARY INFORMATION.  THE X-Y DATA TO BE FITTED MAY BE ENTERED BY NAMELIST
OR READ FROM A FORMATTED DISC FILE.  PROGRAM LSPRWC WILL ALSO EVALUATE THE
RESULTANT LEAST SQUARES POLYNOMIAL AT PRESCRIBED VALUES OF X WHICH, AGAIN,
MAY BE ENTERED BY NAMELIST OR READ FROM A FORMATTED DISK FILE.

                - ENTER/RETURN TO CONTINUE -


SELECT THE SOURCE OF INPUT FOR THE X-Y DATA TO BE FITTED FROM
THE FOLLOWING LIST:

1, FOR KEYBOARD INPUT VIA NAMELIST
2, FOR FORMATTED DISK FILE INPUT

NOTE: THE X-Y DATA MUST BE MONATONICALLY INCREASING IN X.
2

DATA SETS ARE INPUT FROM FORMATTED DISK FILES AS (X,Y) PAIRS WHERE:

X      = X VALUE
Y      = Y VALUE

INPUT THE FILE NAME OF THE FORMATTED DISK FILE DATA SET.
trajectory.dat

INPUT THE DATA FILE FORMAT (INCLUDE PARENTHESES)
NOTE: AN EXAMPLE FORMAT IS "(2E15.6)"
      ENTER"(*)" FOR A FREE FIELD READ (DEFAULT FORMAT)
(E15.6,T61,E15.6)

SHOULD THE X-Y DATA BE DISPLAYED FOR VERIFICATION? (Y/N)
n
```

Figure D-6. LSPRWC Screen Shot—Part 1

```
ARE CONSTRAINTS DESIRED? (Y/N)
y

SELECT THE SOURCE OF INPUT FOR THE CONSTRAINTS FROM THE FOLLOWING LIST:

1, FOR KEYBOARD INPUT VIA NAMELIST
2, FOR FORMATTED DISK FILE INPUT

NOTE: THE CONSTRAINTS ARE COMPLETELY INDEPENDENT OF THE X-Y DATA POINTS TO BE
FITTED.
1

INPUT THE CONSTRAINTS (20 MAX) BY NAMELIST WHERE:

CV     = ARRAY OF POLYNOMIAL DERIVATIVE VALUES
NC     = ARRAY OF POLYNOMIAL DERIVATIVE ORDERS (CONSTRAINT ORDER)
XC     = ARRAY OF POLYNOMIAL DERIVATIVE LOCATIONS (CONSTRAINT X VALUES)

NOTE: NC VALUES MUST BE IN THE RANGE 0 TO NP.

 CURRENT VALUES ARE:

$PARM CV=____,____,____,NC=____,____,____,XC=____,____,____$

XC=2*0.0,NC=0,1,CV=2*0.0$

SHOULD THE CONSTRAINTS BE DISPLAYED FOR VERIFICATION? (Y/N)
Y

     NO.                  XC(I)   NC(I)                  CV(I)
         1    0.0000000000000D+00      0    0.0000000000000D+00
         2    0.0000000000000D+00      1    0.0000000000000D+00

                - ENTER/RETURN TO CONTINUE -


INPUT THE POLYNOMIAL ORDER BY NAMELIST WHERE:

NP = THE POLYNOMIAL ORDER

NOTE: NP MUST BE IN THE RANGE OF 0 TO 9.
      THERE MUST BE AT LEAST NP+NCONST+1 X-Y DATA POINTS.
      THE MAXIMUM VALUE FOR NP IS     9.

CURRENT VALUES ARE:
 $PARM     NP =            3$

NP=2$
      LEAST SQUARES POLYNOMIAL

                P(X)=B(0)+B(1)*X+B(2)*X**2+....+B(NP)*X**NP

                   I            B(I)

                   0      0.0000000000000D+00
                   1      0.0000000000000D+00
                   2      4.9614940868317D+00

   THE STANDARD DEVIATION FOR THIS POLYNOMIAL OF ORDER 2 IS  8.03870D-01

                - ENTER/RETURN TO CONTINUE -
```

Figure D-7. LSPRWC Screen Shot—Part 2

```
SHOULD DATA POINTS BE PRESCRIBED FOR EVALUATION OF THE LEAST SQUARES
POLYNOMIALS? (Y/N)
y

SELECT THE SOURCE OF INPUT FOR THE X DATA TO BE EVALUATED FROM THE FOLLOWING
LIST:

1, FOR KEYBOARD INPUT VIA NAMELIST
2, FOR FORMATTED DISK FILE INPUT
3, FOR INPUT OF MINIMUM, MAXIMUM, AND INTERVAL VALUES
3

INPUT THE X DATA MAXIMUM, MINIMUM, AND INTERVAL VALUES BY NAMELIST WHERE:

XINT   = X DATA POINT INTERVAL
XMAX   = MAXIMUM X DATA VALUE
XMIN   = MINIMUM X DATA VALUE

CURRENT VALUES ARE:
 $PARM   XINT =  0.142784E-01,         XMAX =  0.142784E+01,
         XMIN =  0.000000E+00$



SHOULD THE X-Y DATA BE DISPLAYED FOR VERIFICATION? (Y/N)
n

SHOULD THE RESULTS OF THIS RUN BE QUICK-PLOTTED? (Y/N)
n

ENTER:
1, TO RESTART THE PROGRAM
2, TO CHANGE THE CONSTRAINTS
3, TO CHANGE THE POLYNOMIAL ORDER
4, TO CHANGE THE PRESCRIBED X VALUES FOR EVALUATION OF THE POLYNOMIAL
5, TO PLOT THE RESULTS
6, TO SAVE THE RESULTS ON A FORMATTED DISC FILE
7, TO STOP
6

INPUT THE FILE NAME OF THE FORMATTED DISK FILE.
np2_c.dat

SELECT THE TYPE OF OUTPUT FOR THE FORMATTED DISK FILE FROM THE FOLLOWING LIST:
1, FOR ALL INPUT DATA AND RESULTS
2, FOR ONLY THE EVALUATED DATA
2

INPUT THE EVALUATED DATA VARIABLE LIST FOR OUTPUT BY NAMELIST WHERE:

"X"    = X VALUES
"0"    = 0th DERIVATIVE OF Y AT X
"1"    = 1th DERIVATIVE OF Y AT X
"2"    = 2th DERIVATIVE OF Y AT X
"R"    = RADIUS OF CURVATURE AT X
"S"    = ARC LENGTH

NOTE: VARIABLES WILL BE LISTED IN THE ORDER OF INPUT

CURRENT VALUES ARE:

$PARM AList= "X","0"$

AList="X","0","1","2"$
```

Figure D-8. LSPRWC Screen Shot—Part 3

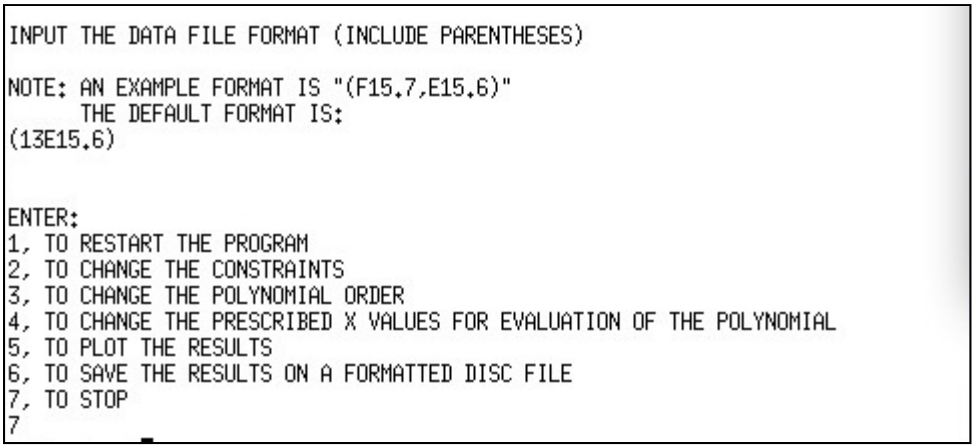

Figure D-9. LSPRWC Screen Shot—Part 4

Following along through Figure D-6, the user was presented with the introduction to LSPRWC, the data source was selected as a formatted disk file, and the file name and read format were entered.

Continuing through Figure D-7, the code asked if problem constraints were desired and a positive response was entered with the constraints defined by means of NAMELIST. The constraints were then displayed for verification to confirm that the 0^{th} and 1^{st} derivatives were set to zero at time zero. The polynomial order was again set to $n_p = 2$ and with the problem thus fully defined, program LSPRWC returned values for the coefficients of the least squares regression polynomial.

Following now through Figure D-8, this second-order regression polynomial was evaluated at specific values of x again using the minimum, maximum, and interval option. Menu options were then chosen to output the evaluated data to a formatted disk file writing, in order, each value of x, y, and the 1^{st} and 2^{nd} derivatives.

Finally, in Figure 9, the LSPRWC code menu option was selected for program termination.

The results from this LSPRWC run are shown in Figure D-10 as plots of displacement and velocity as a function of time along with the true values and the measurements of Table D-1. This 2^{nd} order least squares regression polynomial agrees exceptionally well with the true relations for displacement and velocity having constraints imposed to satisfy equations (6) and (7).

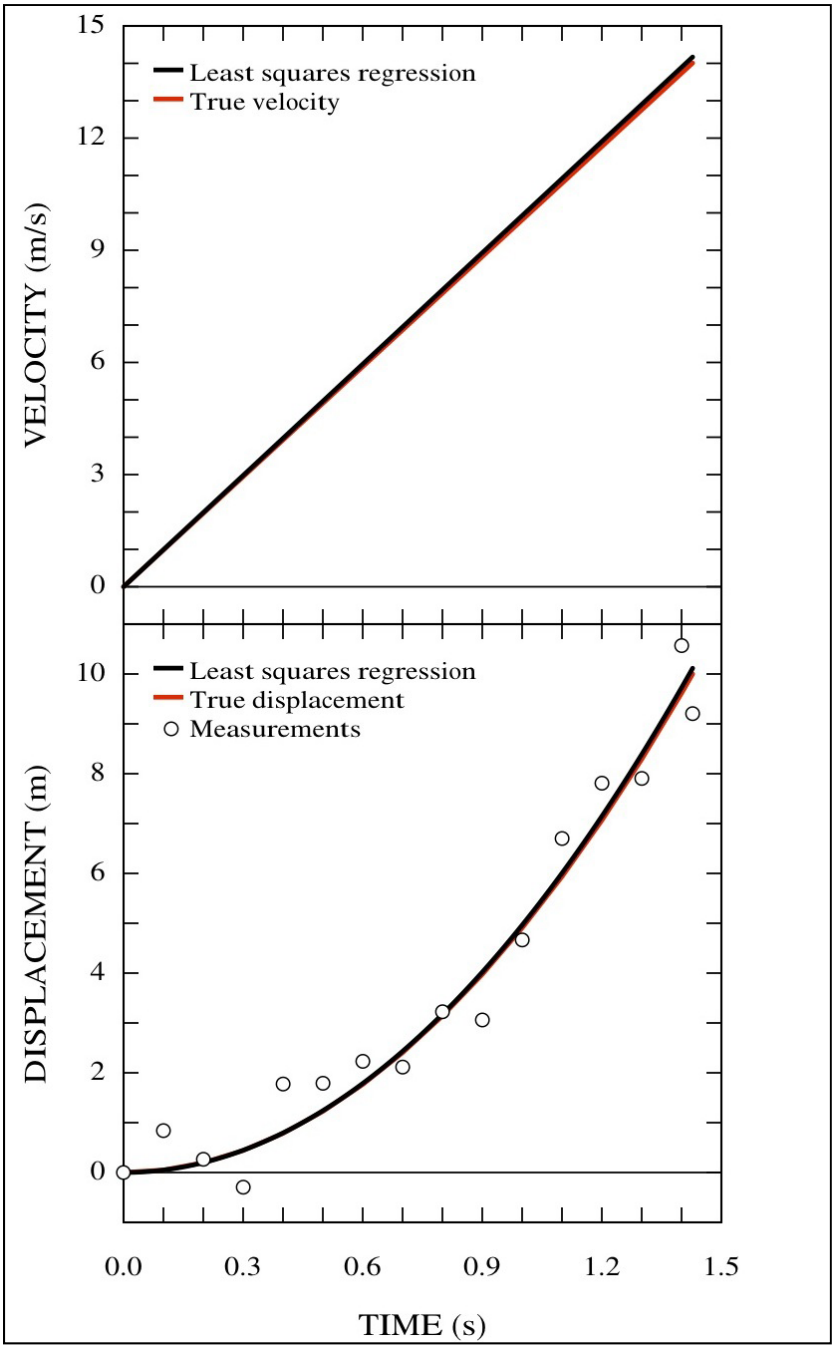

Figure D-10. Least Squares Polynomial Regression for $n_p = 2$ with Constraints

Indeed, the polynomial coefficients b_0 and b_1 are now zero valued, as shown in Figure D-7. Furthermore, the acceleration, $a = 2 \times b_2 = 9.92$ m/s^2, is much closer to the true value of 9.81 m/s^2 demonstrating the value of added constraints to the least squares polynomial regression procedure when they are known.

APPENDIX E
EXAMPLE 2

For this example, the LSPRWC code was applied to the representation of a set of observations artificially generated through the application of random dispersions to a hyperbolic spiral. The hyperbolic spiral in polar coordinates is given by

$$R = a/\theta \tag{1}$$

or in Cartesian coordinates

$$x = a/cos(\theta), \tag{2}$$

$$y = a/sin(\theta), \tag{3}$$

where

a = constant,
R = radius,
θ = angle,
x = ordinate,
y = absicca.

A partial list of the observations for this example are given in Table E-1, along with the true values for the x and y coordinates. Note that these observations were generated using equation (1) for equal 1° increments of θ from 90° through 720° with a dispersion applied to R within a uniformly distributed random resolution. These polar coordinates were then converted to Cartesian coordinates to produce the values given in Table E-1.

Table E-1. Observations, Cartesian Coordinates

True X	True Y	Measured X	Measured Y
0.000000E+00	0.636620E+00	0.000000E+00	0.637909E+00
-0.109885E-01	0.629528E+00	-0.106533E-01	0.610330E+00
-0.217347E-01	0.622401E+00	-0.207991E-01	0.595609E+00
-0.322433E-01	0.615239E+00	-0.328693E-01	0.627184E+00
-0.425186E-01	0.608045E+00	-0.434283E-01	0.621054E+00
-0.525648E-01	0.600818E+00	-0.500020E-01	0.571525E+00
-0.623858E-01	0.593562E+00	-0.630342E-01	0.599730E+00
-0.719856E-01	0.586275E+00	-0.722125E-01	0.588124E+00
-0.813677E-01	0.578961E+00	-0.751539E-01	0.534748E+00
-0.905357E-01	0.571620E+00	-0.929371E-01	0.586782E+00
-0.994931E-01	0.564253E+00	-0.984405E-01	0.558284E+00
-0.108243E+00	0.556862E+00	-0.113103E+00	0.581865E+00
-0.116789E+00	0.549448E+00	-0.118323E+00	0.556665E+00
-0.125133E+00	0.542013E+00	-0.128515E+00	0.556658E+00
-0.133280E+00	0.534556E+00	-0.139035E+00	0.557639E+00
-0.141231E+00	0.527081E+00	-0.143160E+00	0.534281E+00
-0.148989E+00	0.519587E+00	-0.157430E+00	0.549024E+00
-0.156558E+00	0.512077E+00	-0.161426E+00	0.528002E+00
-0.163939E+00	0.504551E+00	-0.171451E+00	0.527671E+00
-0.171135E+00	0.497011E+00	-0.169825E+00	0.493208E+00
-0.178148E+00	0.489458E+00	-0.163469E+00	0.449128E+00
	********		
	********		
0.772813E-01	-0.266101E-01	0.486087E-01	-0.167373E-01
0.776233E-01	-0.252213E-01	0.119837E+00	-0.389375E-01
0.779406E-01	-0.238288E-01	0.115467E+00	-0.353019E-01
0.782333E-01	-0.224330E-01	0.112810E+00	-0.323478E-01
0.785014E-01	-0.210344E-01	0.424245E-01	-0.113676E-01
0.787448E-01	-0.196333E-01	0.323353E-01	-0.806209E-02
0.789636E-01	-0.182302E-01	0.126867E+00	-0.292896E-01
0.791578E-01	-0.168255E-01	0.104055E+00	-0.221176E-01
0.793274E-01	-0.154197E-01	0.893899E-01	-0.173756E-01
0.794723E-01	-0.140131E-01	0.111402E+00	-0.196431E-01
0.795926E-01	-0.126062E-01	0.818384E-01	-0.129619E-01
0.796885E-01	-0.111995E-01	0.101321E+00	-0.142397E-01
0.797598E-01	-0.979327E-02	0.902876E-01	-0.110859E-01
0.798066E-01	-0.838801E-02	0.470222E-01	-0.494223E-02
0.798290E-01	-0.698413E-02	0.865510E-01	-0.757223E-02
0.798271E-01	-0.558206E-02	0.116908E+00	-0.817499E-02
0.798009E-01	-0.418219E-02	0.421504E-01	-0.220901E-02
0.797505E-01	-0.278495E-02	0.118973E+00	-0.415463E-02
0.796760E-01	-0.139075E-02	0.544780E-01	-0.950917E-03
0.795775E-01	0.000000E+00	0.751481E-01	0.000000E+00
0.795775E-01	0.000000E+00	0.798177E-01	0.000000E+00

The full set of observations from Table E-1 are presented in the plot of Figure E-1 and show immediately that this set of (x, y) data pairs or observations will not be suitable for a least squares polynomial regression. The true position data depicting the hyperbolic spiral, as indicated in red, exhibits locations of infinite slope which cannot be represented with polynomials. Furthermore, the (x, y) observations may well be multivalued for a given x location, as is certainly the case for the hyperbolic spiral. Although artificially generated specifically for this example, similar Cartesian coordinate data sets do occur and pose similar problems for regression.

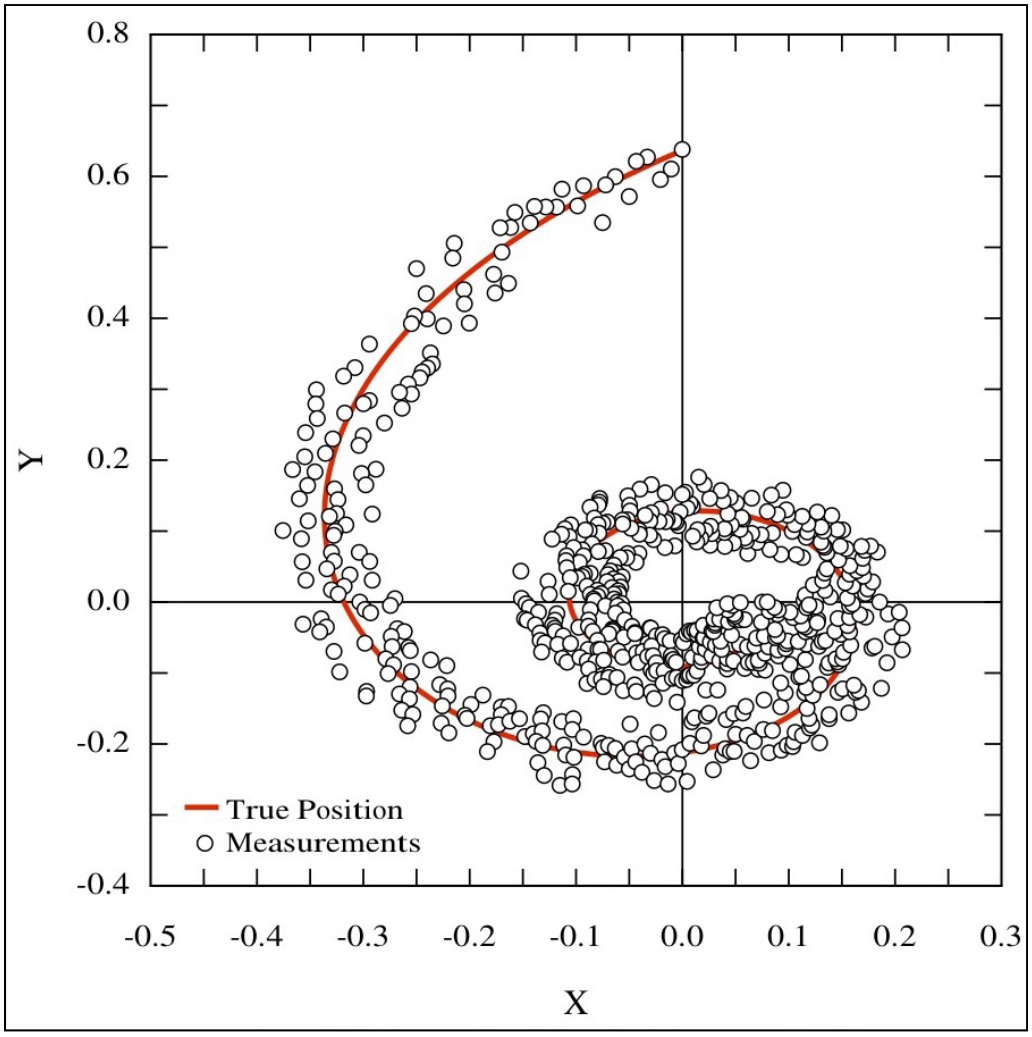

Figure E-1. Measured and True Position in (x, y) Coordinates

Something must be done to fit this (*x*, *y*) data set of Table E-1 with a least squares polynomial regression and this is accomplished, at least for this example, through a coordinate transformation. Figure E-2 shows the data in polar coordinates, data which is clearly well behaved and amenable to treatment with the method of least squares polynomial regression.

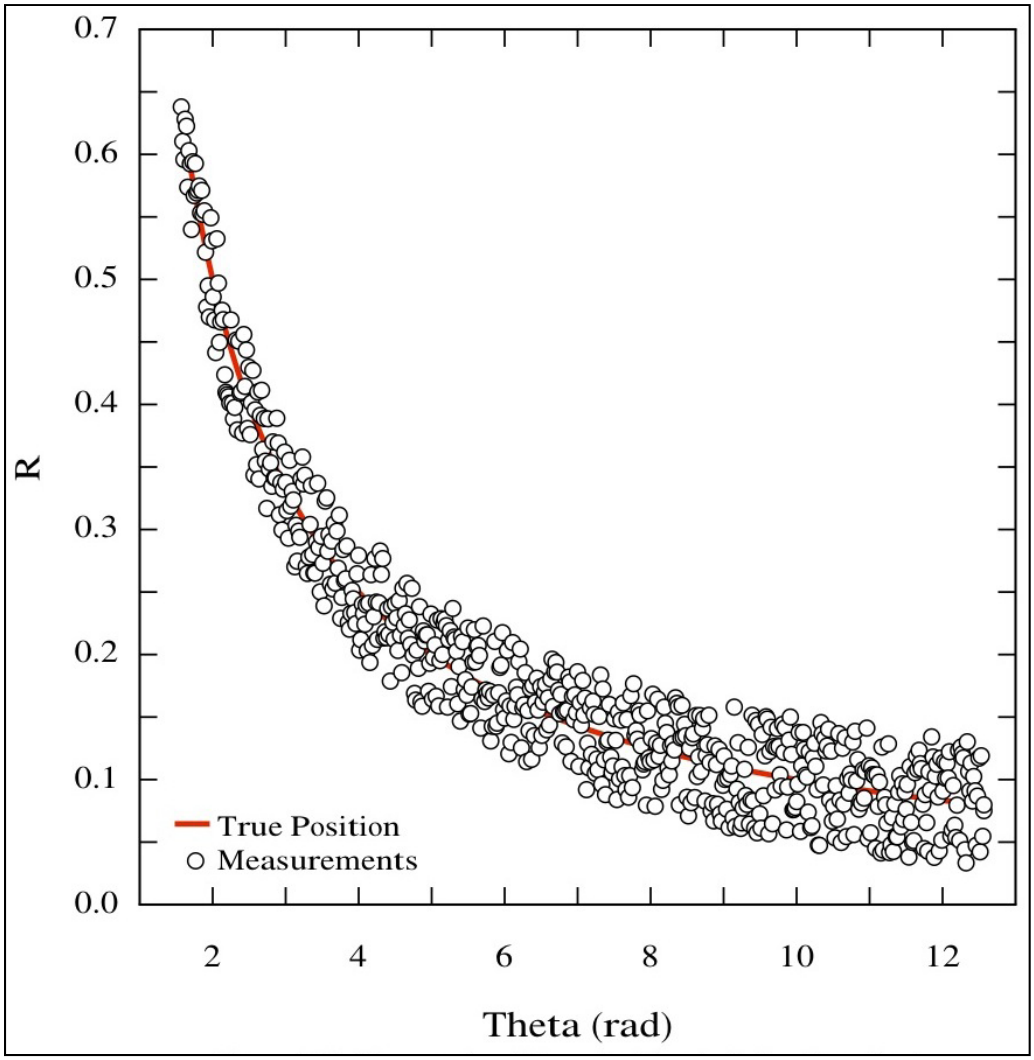

Figure E-2. Measured and True Position in Polar Coordinates

The LSPRWC code was then run with the observations in the polar coordinates of Figure E-2 for polynomial orders from 2 through 5 to produce the results of Figure E-3. This plot of R versus θ shows a reasonable fit for the regression polynomials, although none truly duplicate the hyperbolic spiral a/θ as shown in the figure. Perhaps this should not be unanticipated since R is a function of θ to the -1 power, while the LSPRWC code limits the n_p order regression polynomial, in this case, to

$$R(\theta) = \sum_{j=0}^{n_p} b_j \theta^j$$

for $0 \le n_p \le 9$.

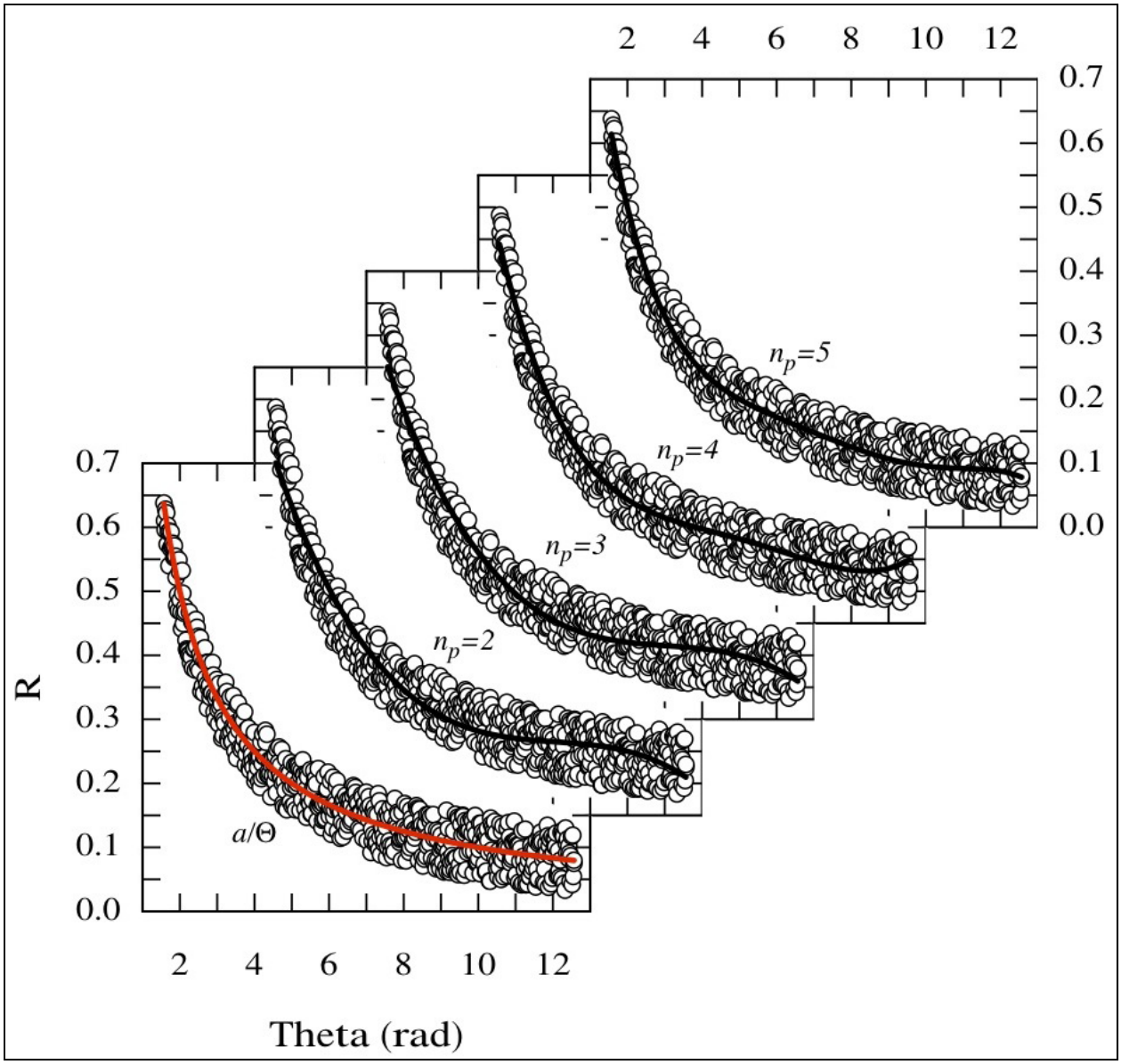

Figure E-3. Least Squares Polynomial Regression for np = 2, 3, 4, 5

Assuming the 5th order regression polynomial to give the best fit, a set of evaluations from that polynomial over the range $90° \leq \theta \leq 720°$ were converted to Cartesian coordinates and plotted in Figure E-4 along with the observations and true values from Table E-1. Surprisingly, the fit is quite good with the largest departure from the theoretical occurring for values of θ near 90° rather than 720°, as might be surmised from Figure E-2.

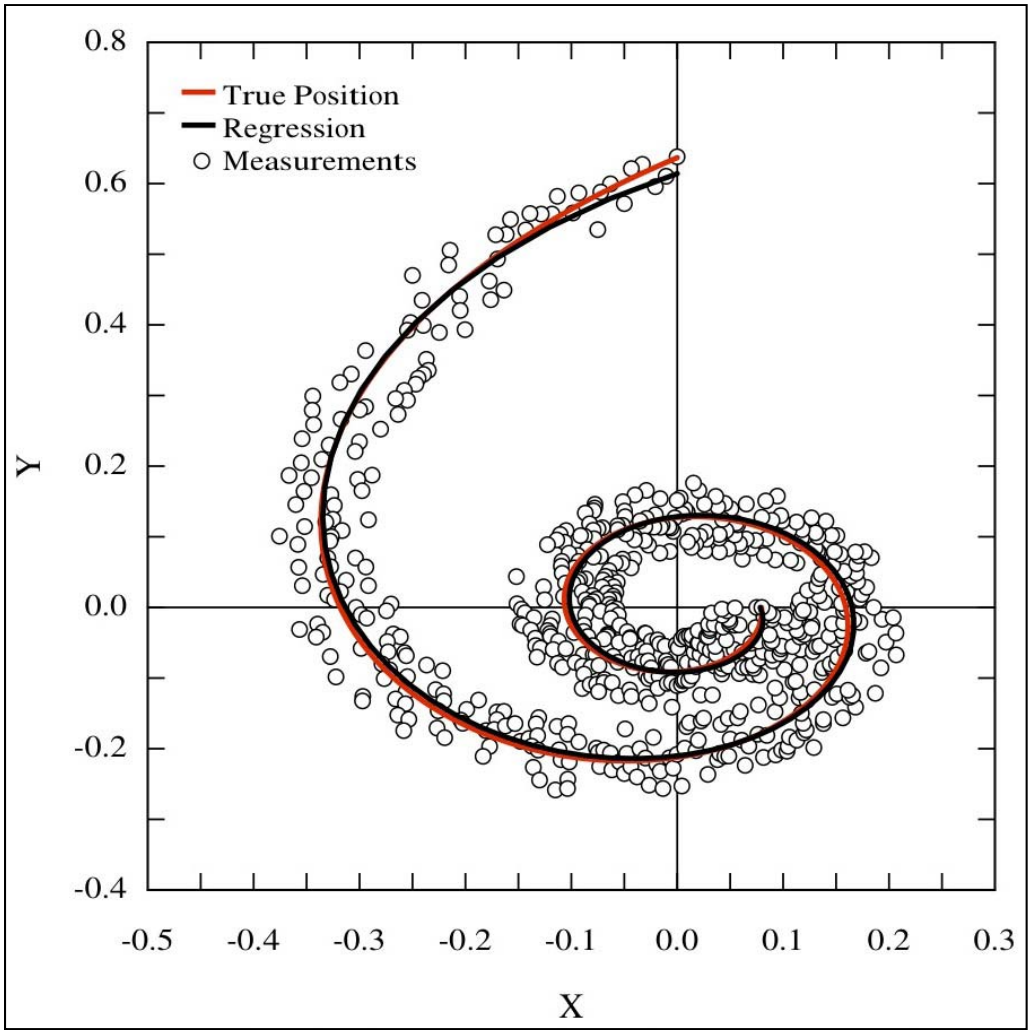

Figure E-4. Least Squares Polynomial Regression for $n_p = 5$

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